
What Am I
Looking At?

Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

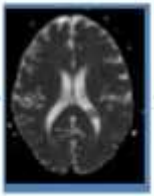
T1

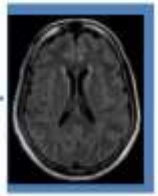
FLAIR

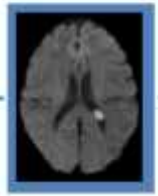
DIFFUSION

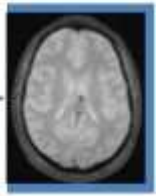
Proton density

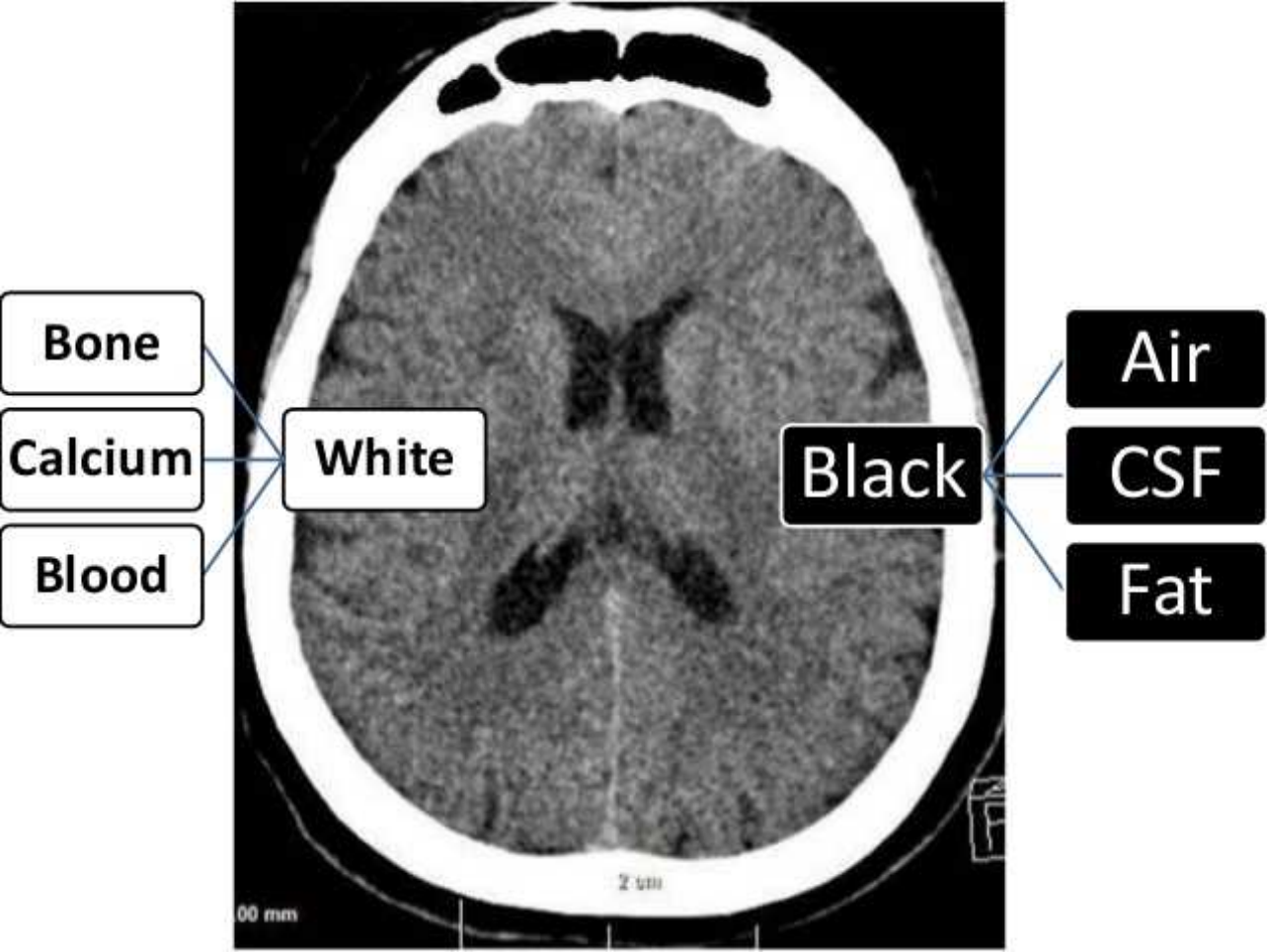
Graident echo









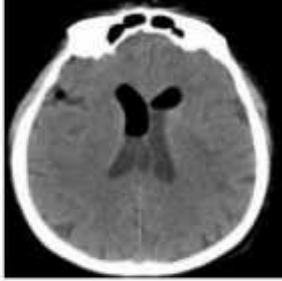

Bone
Calcium
Blood
White
Black
Air
CSF
Fat
2 cm
00 mm

- Bone
- Calcium
- Blood

→ White

Black ←

- Air
- CSF
- Fat



Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

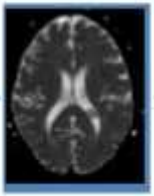
T1

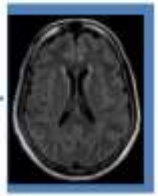
FLAIR

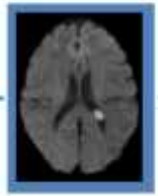
DIFFUSION

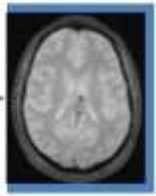
Proton density

Graident echo

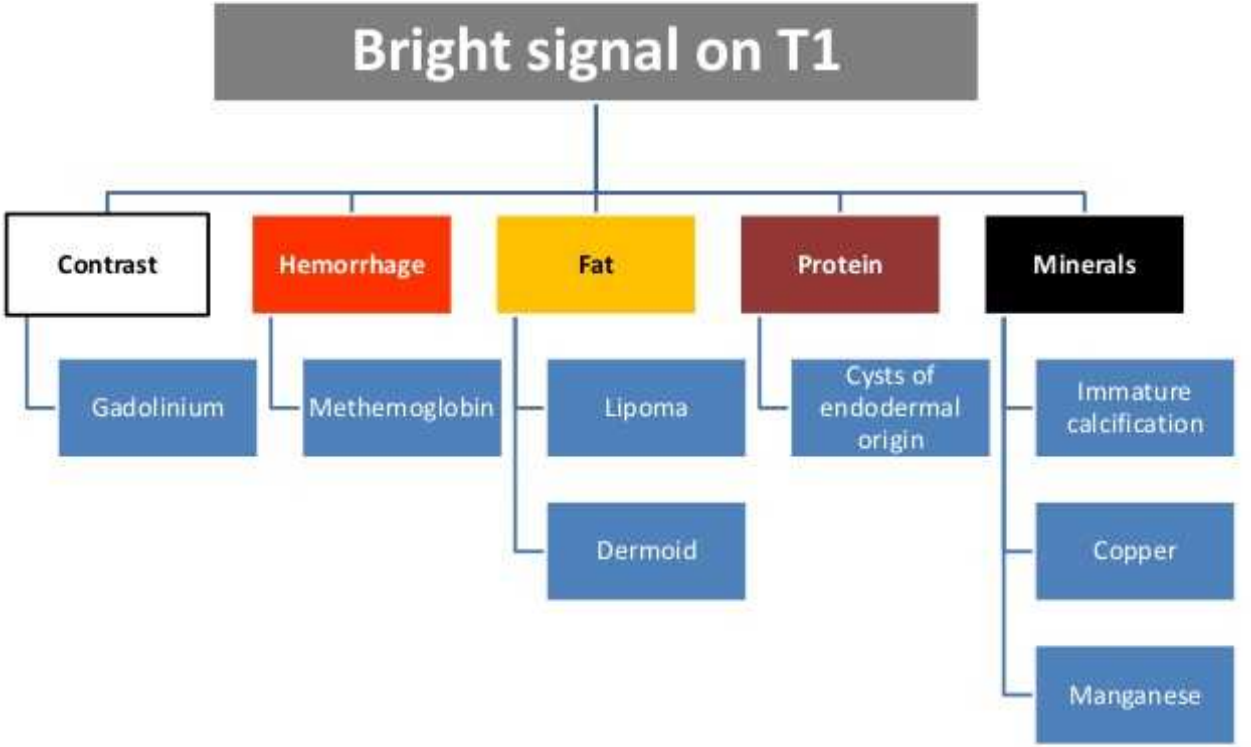




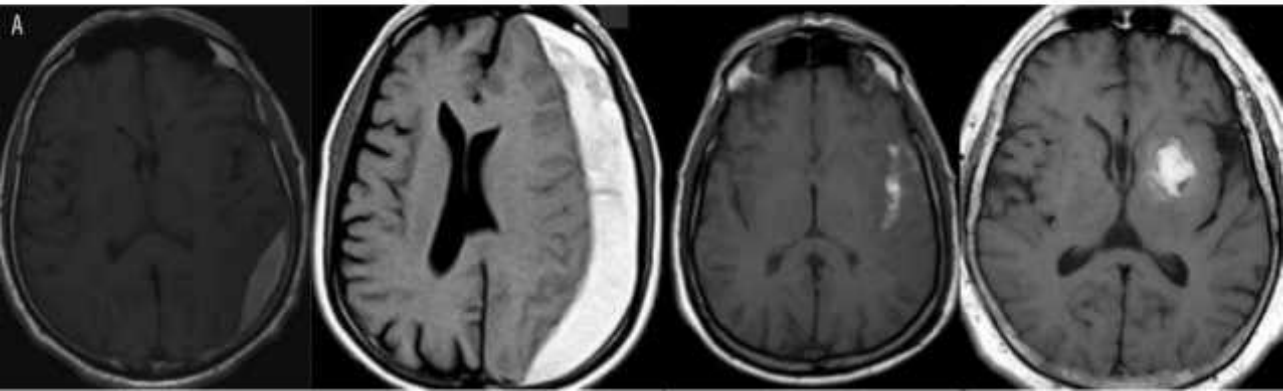




Brain image
Skull is white
Skull is not white
CT
MRI
CSF
white
Black
Grey
T2
ADC
T1
FLAIR
DIFFUSION
Proton density
Graident echo

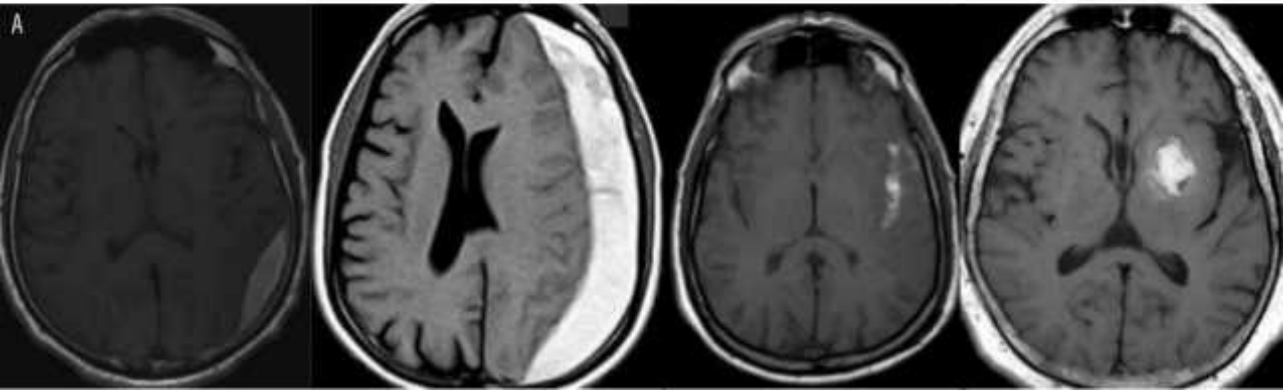

Bright signal on T1
Contrast
Hemorrhage
Fat
Protein
Minerals
Gadolinium
Methemoglobin
Lipoma
Dermoid
Cysts of endodermal origin
Immature calcification
Copper
Manganese

Hemorrhage



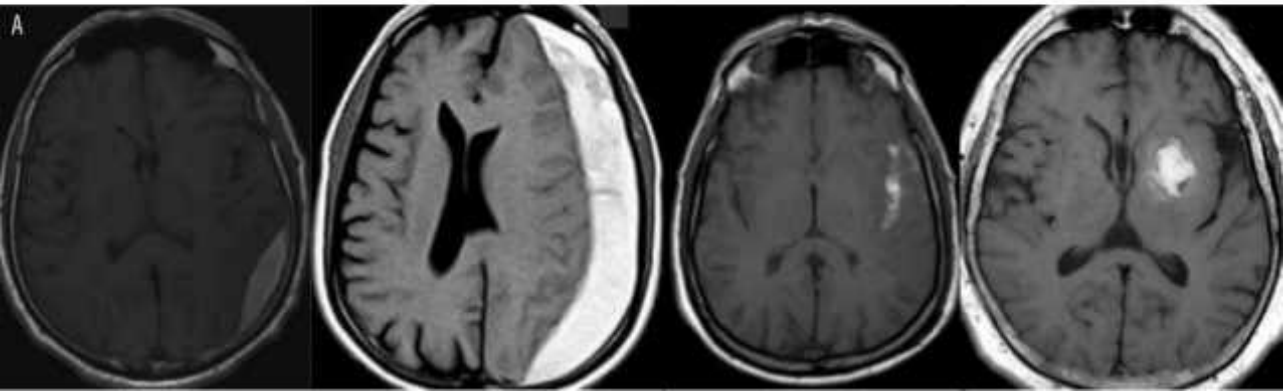
Hemorrhage

Epi-dural



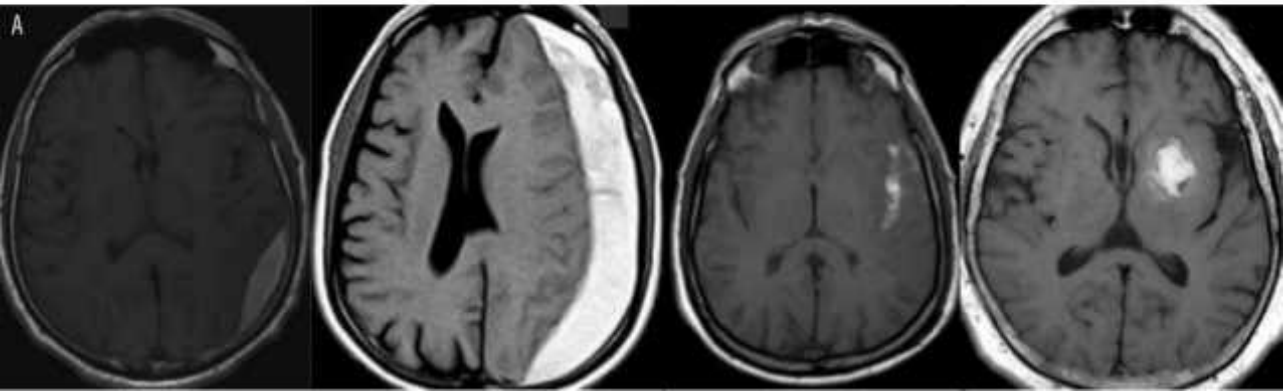
Hemorrhage

- Epi-dural
- Sub-dural
-
-



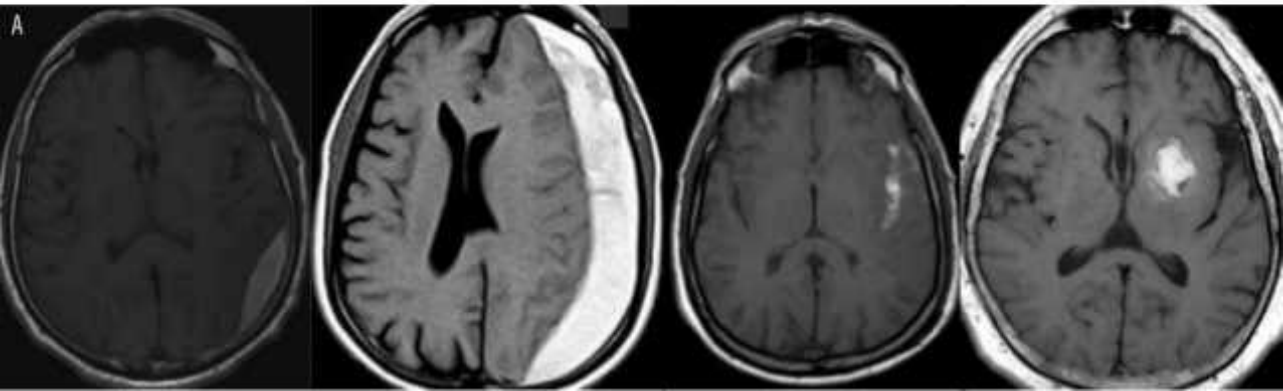
Hemorrhage

- Epi-dural
- Sub-dural
- Sub-arachnoid
-

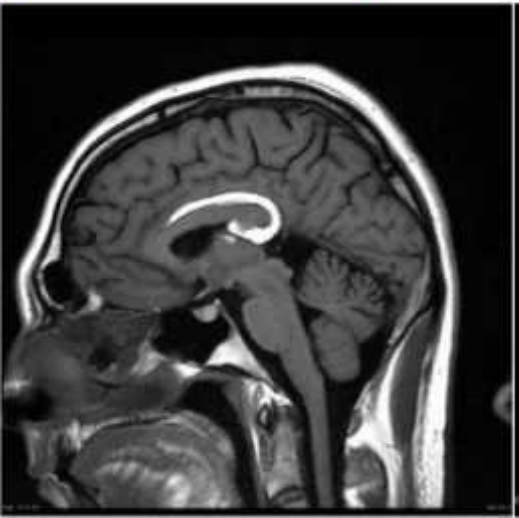


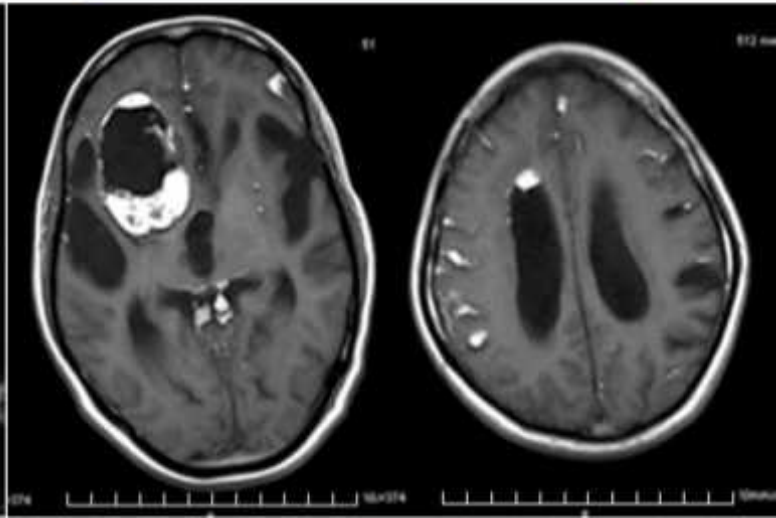
Hemorrhage

- Epi-dural
- Sub-dural
- Sub-arachnoid
- Intra-cerebral



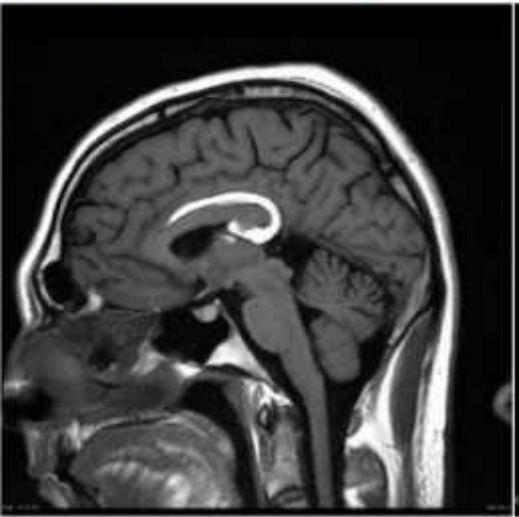
Fat

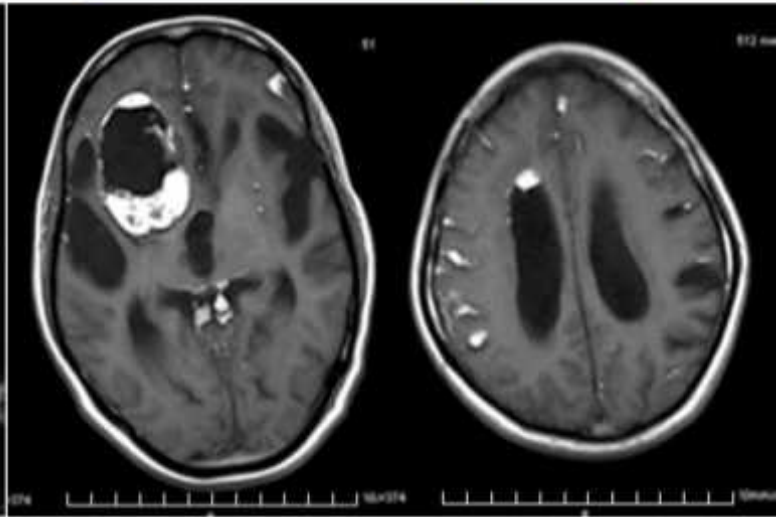




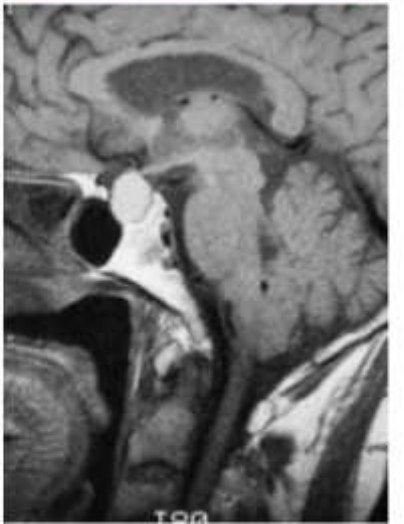
Fat

- Pericallosal lipoma
- Ruptured dermoid cyst



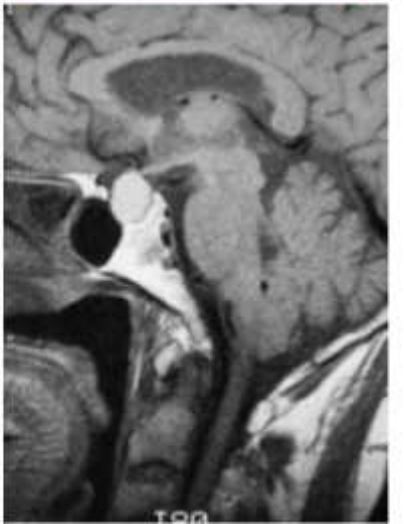


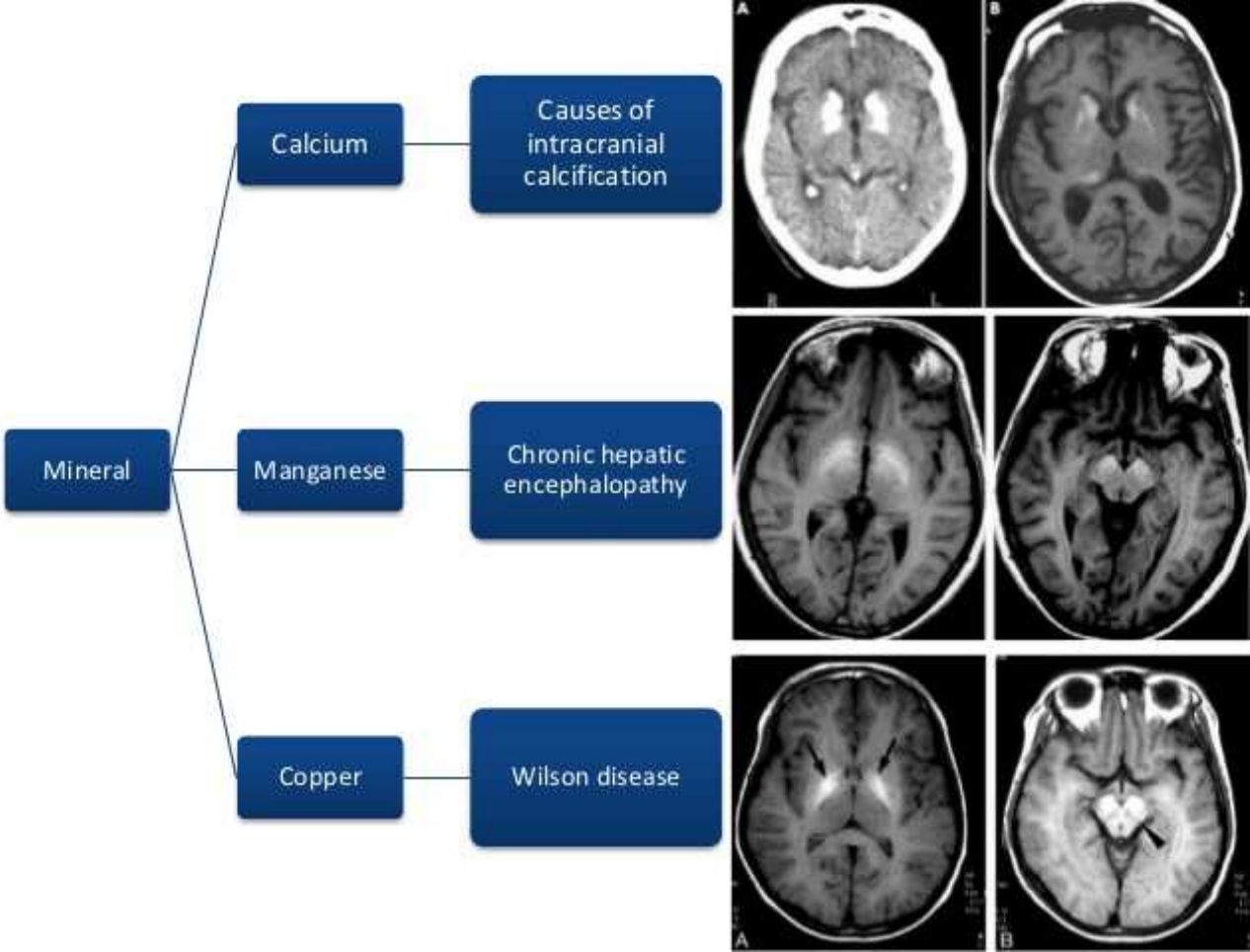
Intracranial cysts of endodermal origin

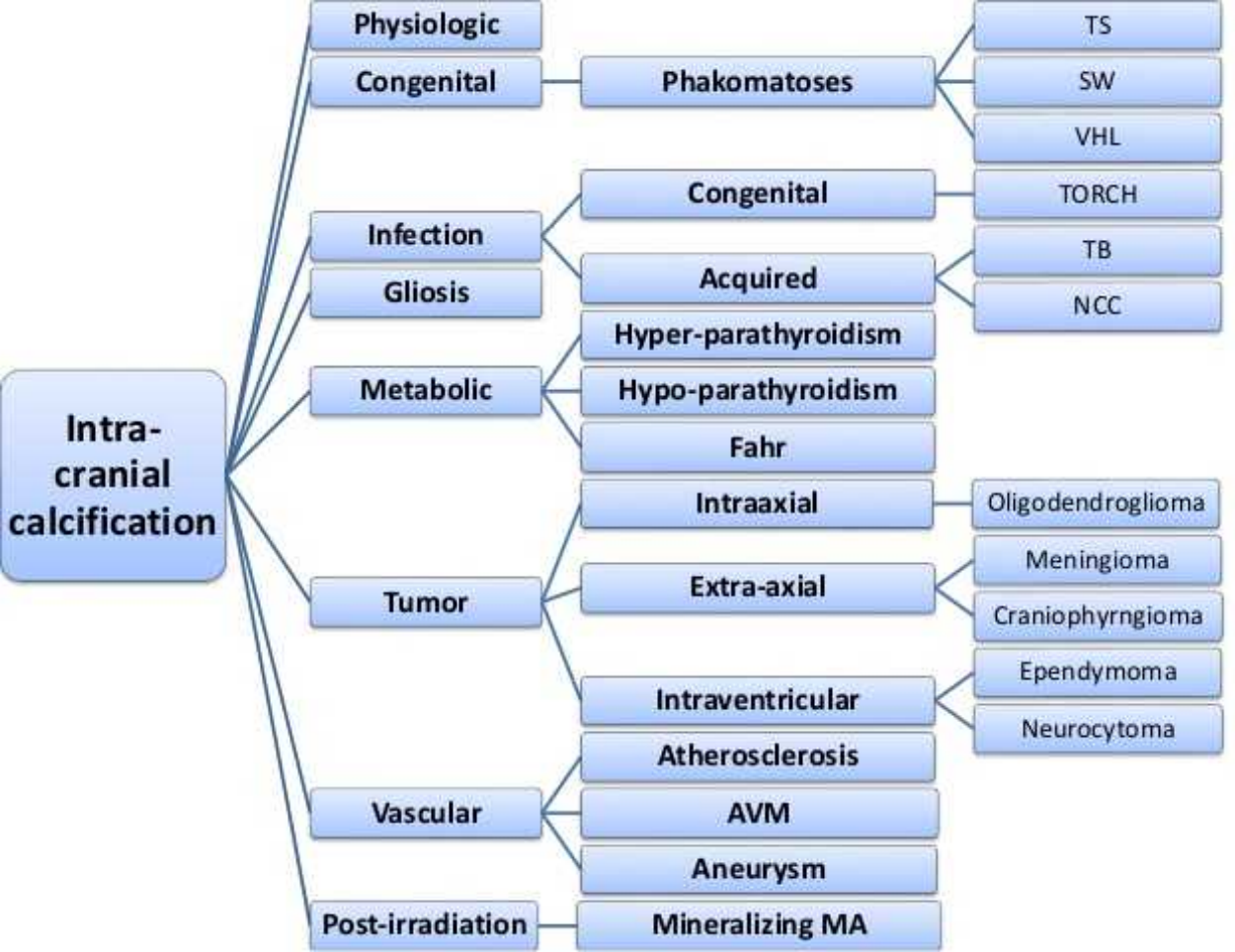


Intracranial cysts of endodermal origin

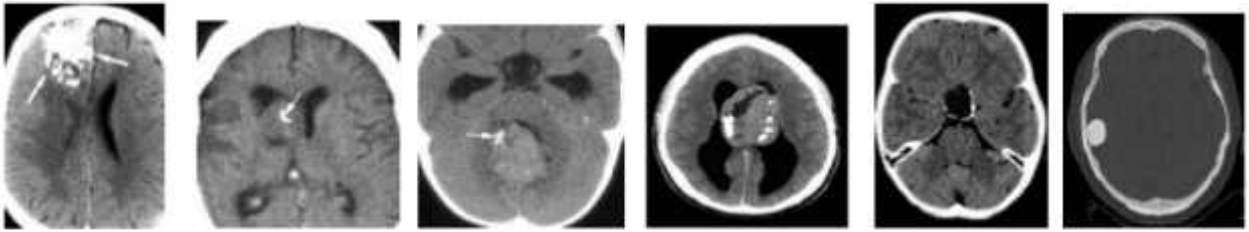
- Colloid cyst
- Rathke's cleft cyst
- Neuroenteric cyst



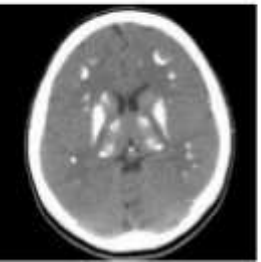

Mineral
Calcium
Causes of intracranial calcification
Manganese
Chronic hepatic encephalopathy
Copper
Wilson disease


Intra-cranial calcification
Physiologic
Congenital
Phakomatoses
TS
SW
VHL
Infection
Congenital
TORCH
Gliosis
Acquired
TB
NCC
Metabolic
Hyper-parathyroidism
Hypo-parathyroidism
Fahr
Tumor
Intraaxial
Oligodendroglioma
Extra-axial
Meningioma
Craniophyrngioma
Intraventricular
Ependymoma
Neurocytoma
Vascular
Atherosclerosis
AVM
Aneurysm
Post-irradiation
Mineralizing MA

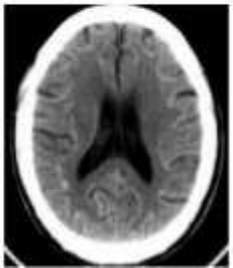
Oligodendro-glioma | Sub-ependymoma | Ependymoma | Central neurocytoma | Cranio-pharyngioma | Meningioma



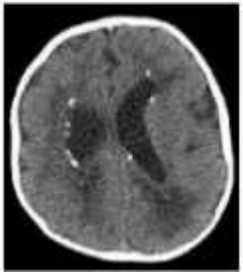
Hyper-parathyroidism



Mineralizing microangiopathy



TORCH



Cavernous malformation

Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

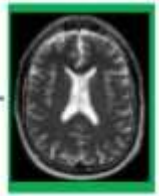
T1

FLAIR

DIFFUSION

Proton density

Graident echo

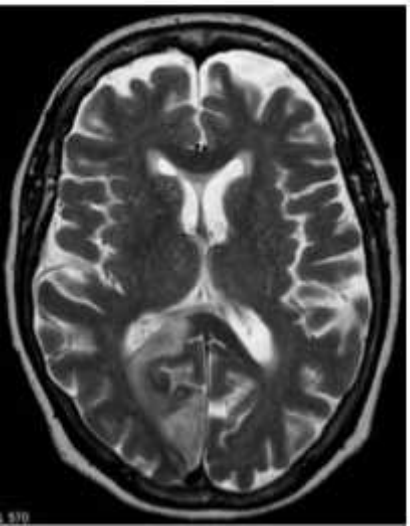


T2

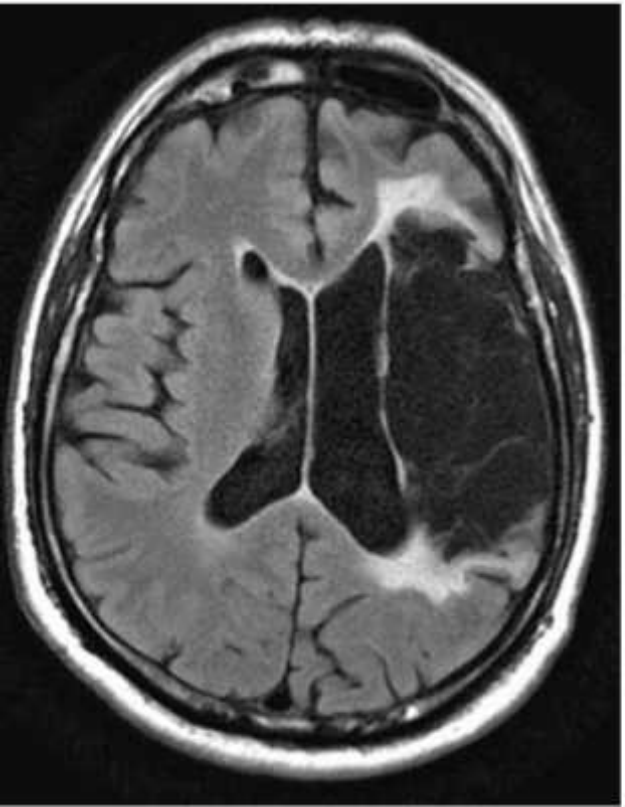
- Brain edema.
- Encephalomalacia / gliosis.
- Demyelination plaques (posterior fossa).

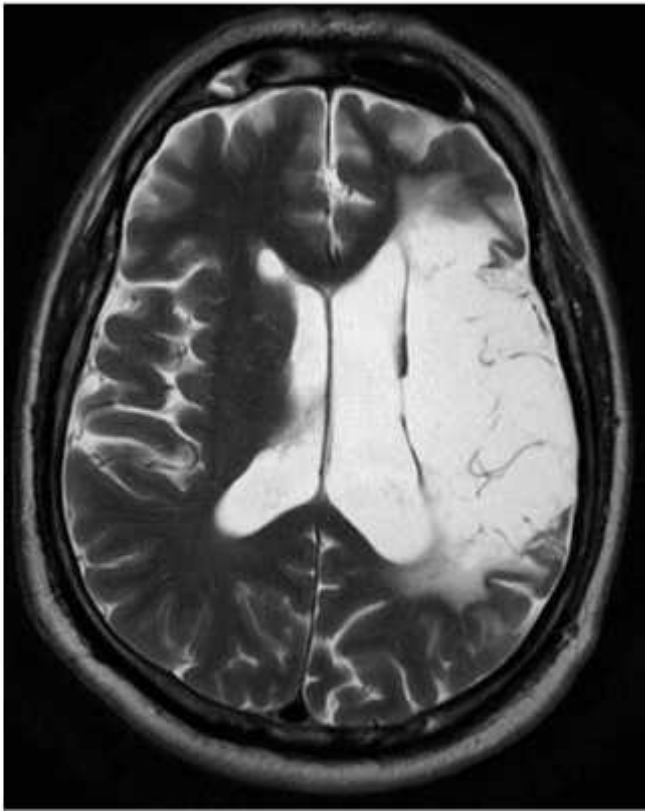
Brain edema

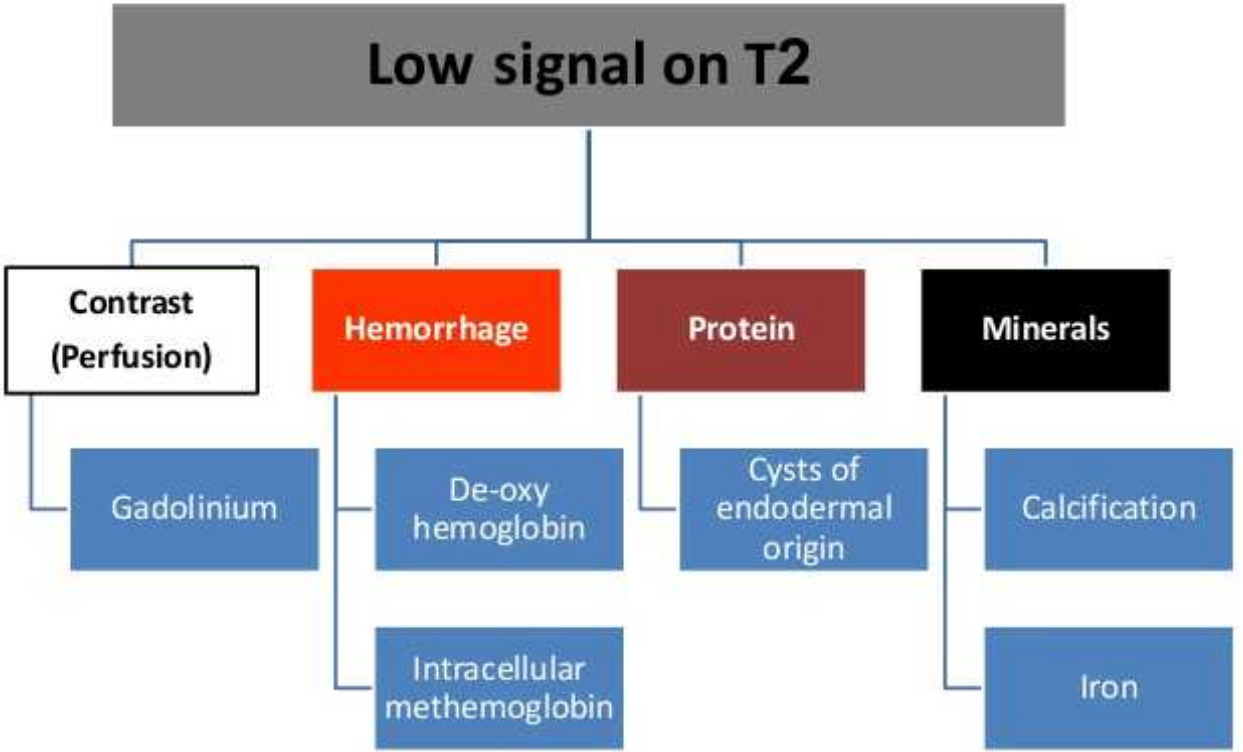
- Cyto-toxic
- Vaso-genic
- Interstitial



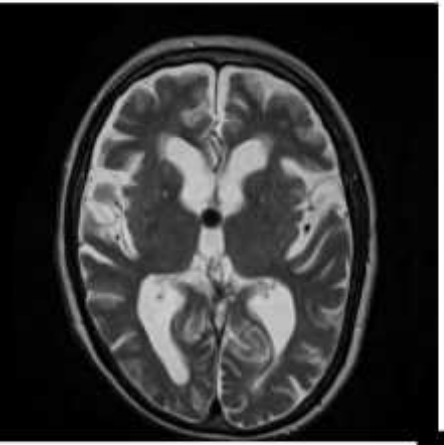
Enephalomalacia vs gliosis



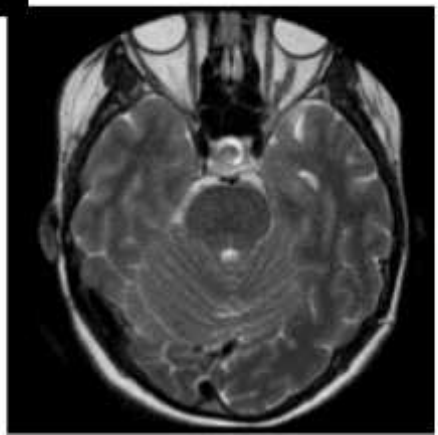


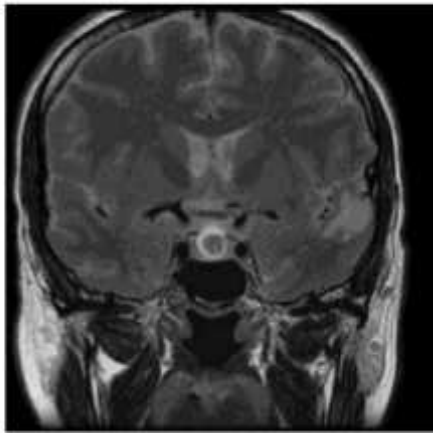

Low signal on T2
Contrast (Perfusion)
Hemorrhage
Protein
Minerals
Gadolinium
De-oxy hemoglobin
Intracellular methemoglobin
Cysts of endodermal origin
Calcification
Iron

Black hole effect

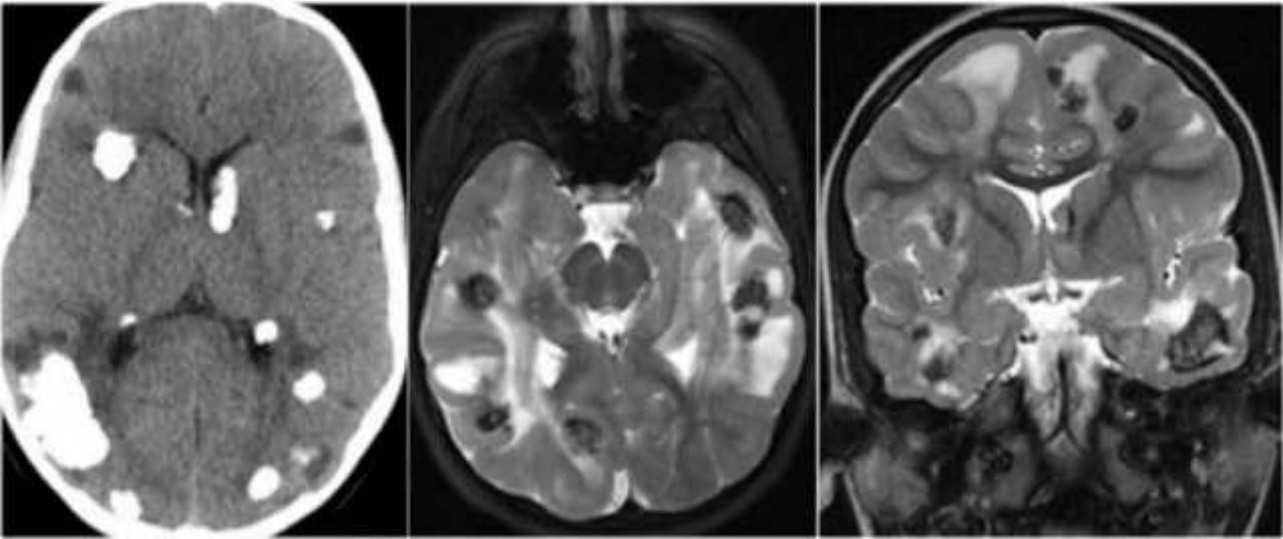


Intra-cystic nodule of low signal



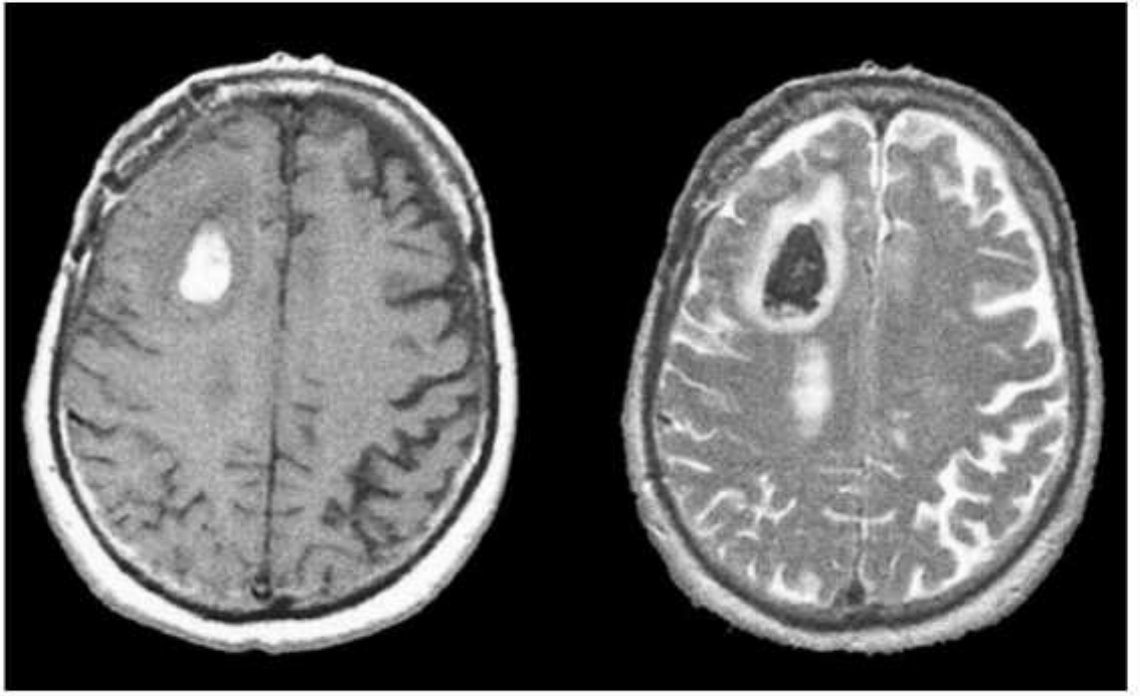


Calcification



Acute intracerebral hematoma

de-oxy hemoblobin



Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

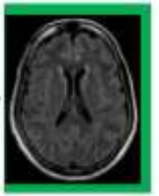
T1

FLAIR

DIFFUSION

Proton density

Graident echo

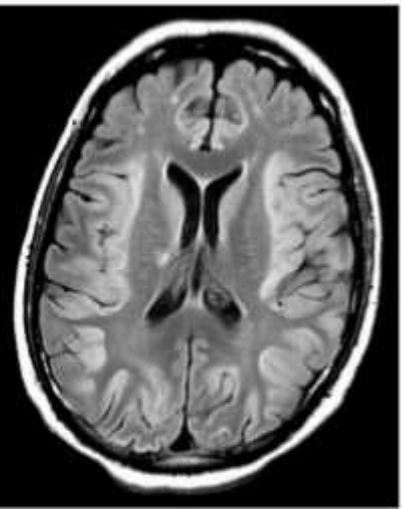


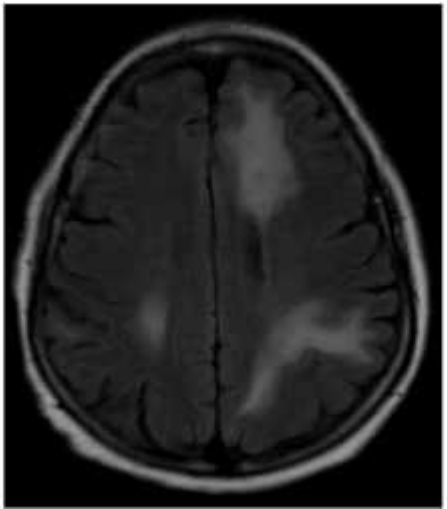
FLAIR

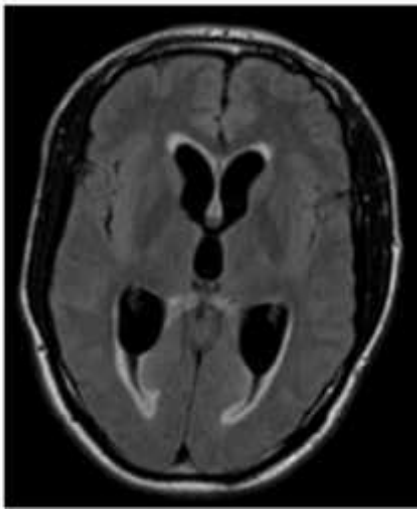
- Brain edema.
- Gliosis.
- Demyelination plaques.
- Subarachnoid hemorrhage.

Brain edema

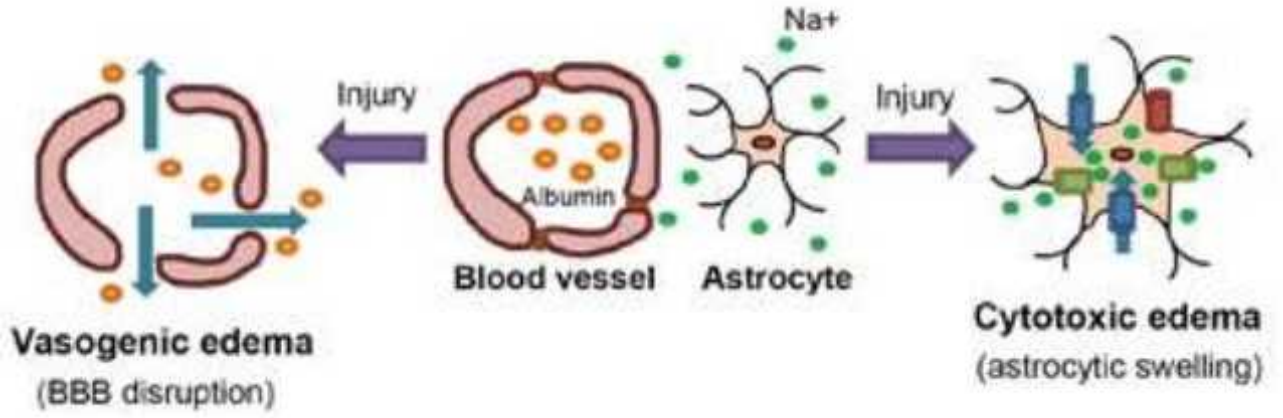
- Cyto-toxic
- Vaso-genic
- Interstitial



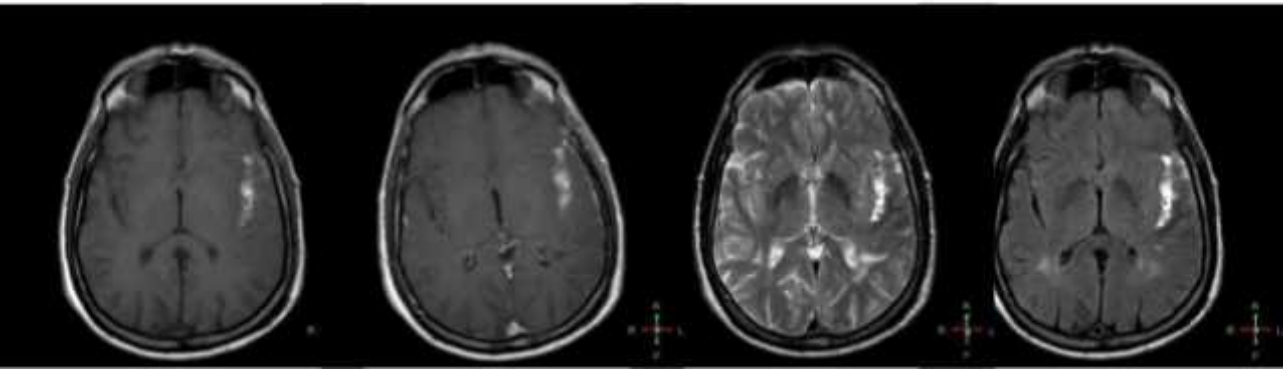




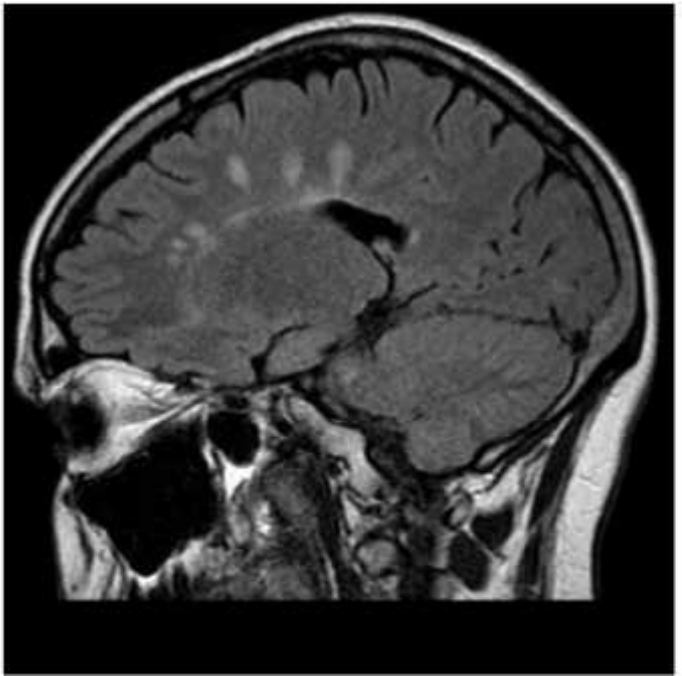
	Cytotoxic	Vasogenic	Interstitial
	Intra-cellular edema	Extra-cellular edema	Trans-ependymal CSF permeation
Pathogenesis	Na / k pump failure	Disrupted BBB	increased intraventricular pressure
Causes	Infarction.	Infarction. Tumor. Infection. PRESS.	Hydrocephalus
Location	Grey and white matter	White matter	Periventricular white matter
T2	Loss of cortiomedullary differentiation	Finger like	Periventricular rim.
Diffusion	Restriction	No restriction	No restriction


Na+
Injury
Albumin
Injury
Blood vessel
Astrocyte
Vasogenic edema
(BBB disruption)
Cytotoxic edema
(astrocytic swelling)

Subarachnoid hemorrhage

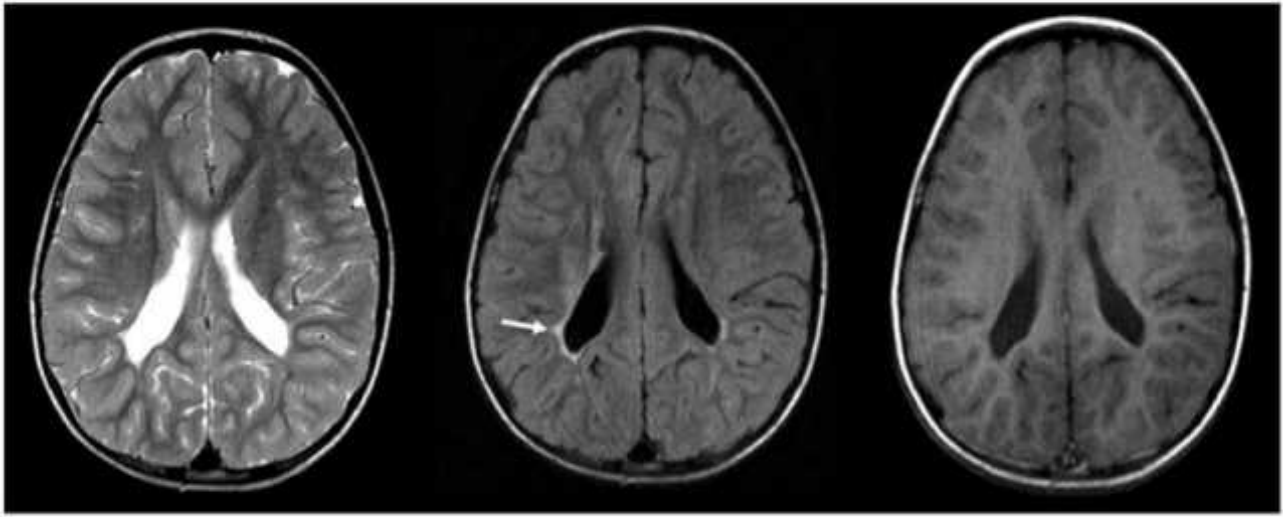


MS



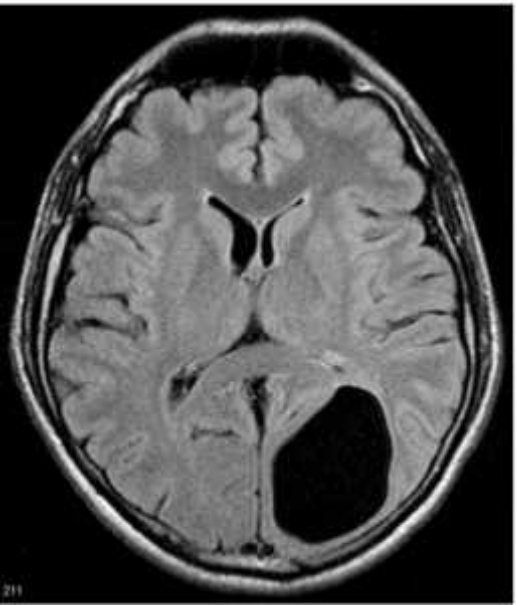
Gliosis

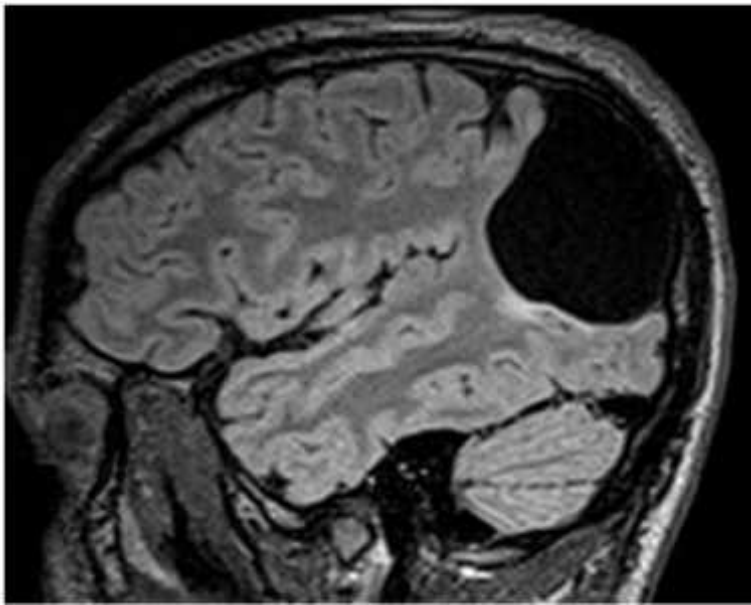
- Periventricular leukomalacia.



Gliosis

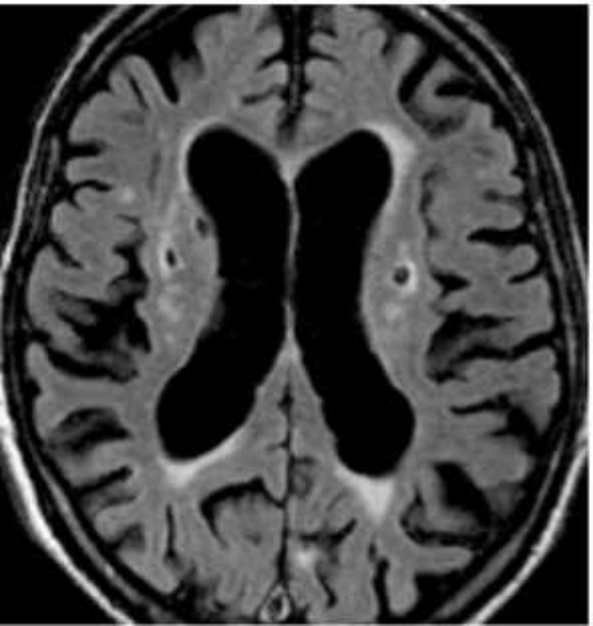
- ***Neuro-epithelial*** cyst Vs ***Porencephalic*** cyst

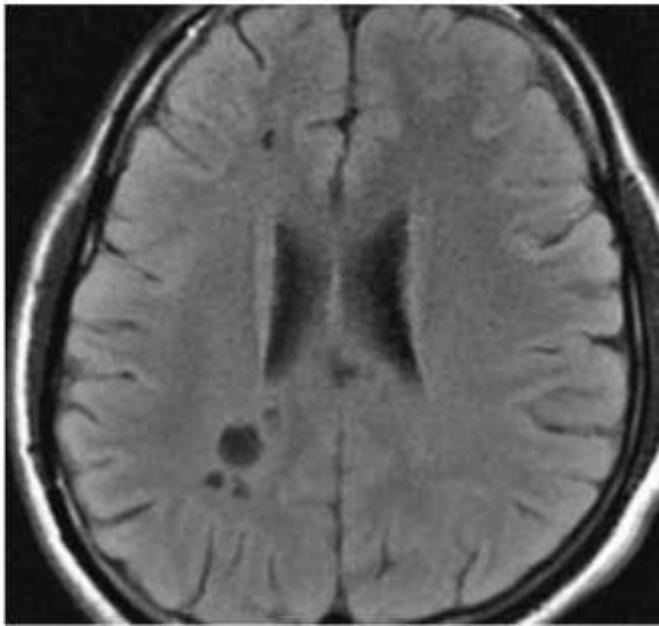




Gliosis

Lacunar infarct vs **Virchow Robin space**

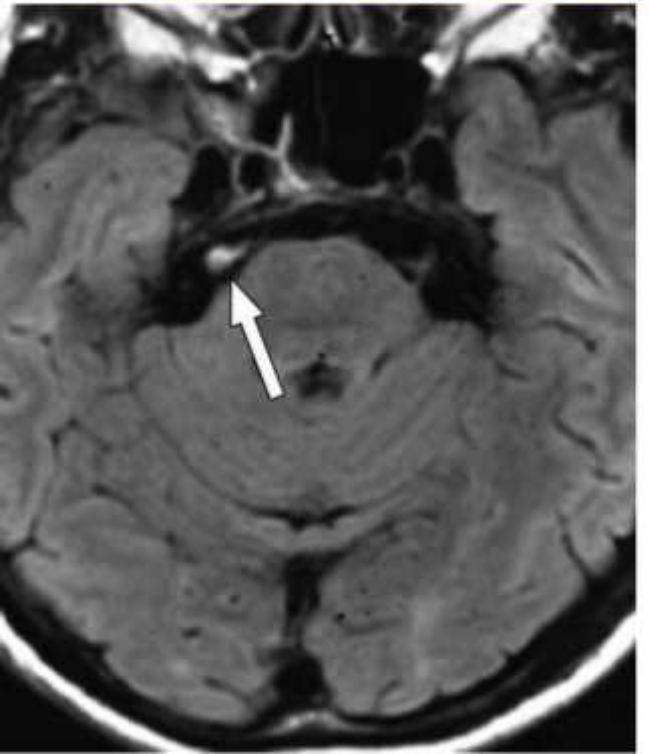


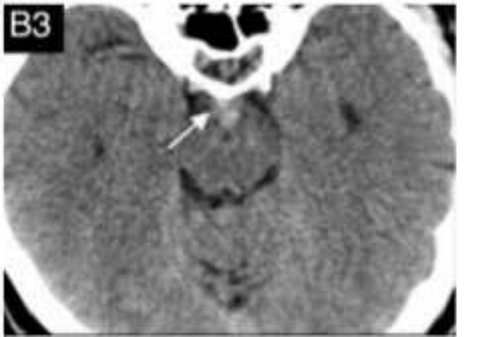


Disadvantages of FLAIR

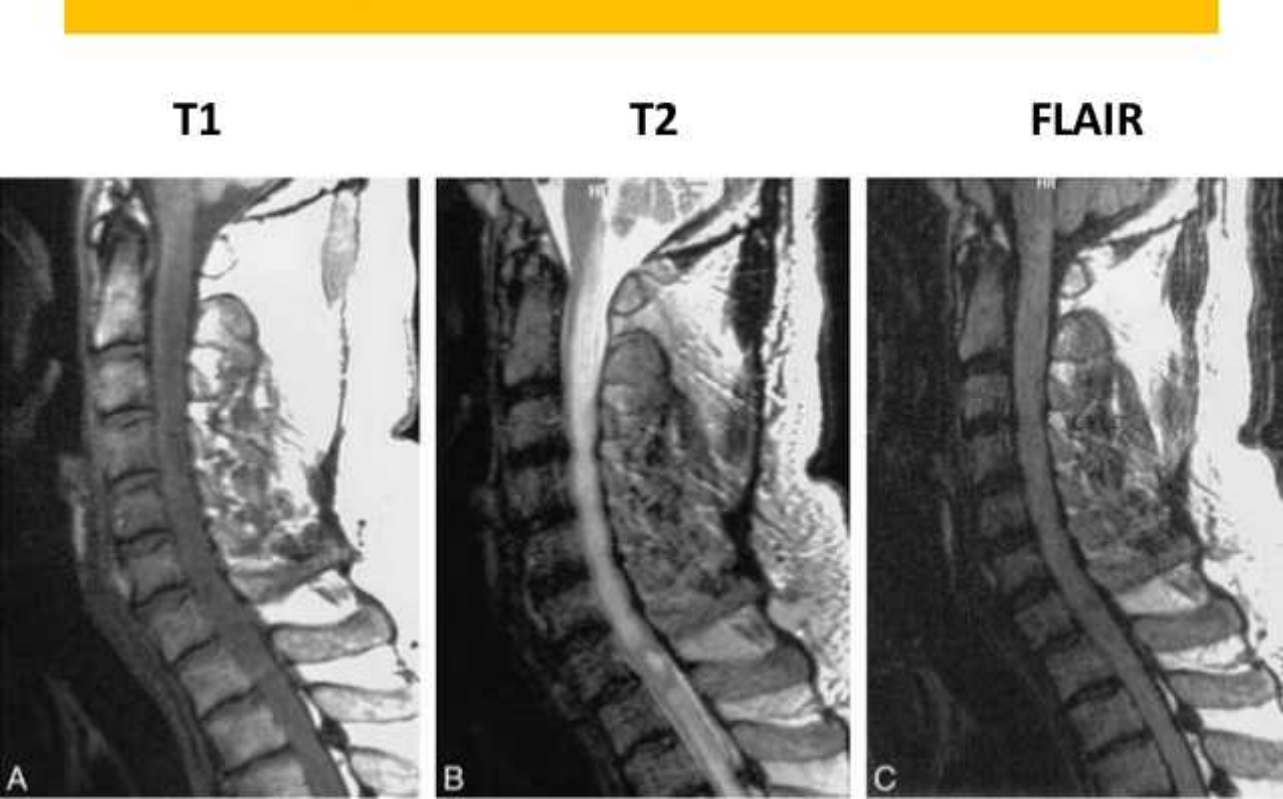
- CSF flow artifact.
- False negative FLAIR.

CSF flow artifact





False negative FLAIR



Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

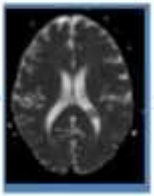
T1

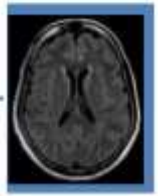
FLAIR

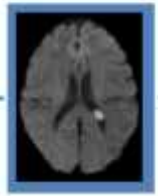
DIFFUSION

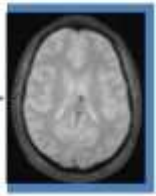
Proton density

Graident echo









Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

T1

FLAIR

DIFFUSION

Proton density

Graident echo

Detection of MS plaques

- ***PD is the king*** under tentorium.

Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

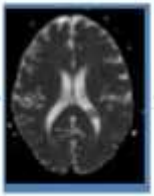
T1

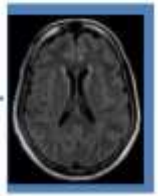
FLAIR

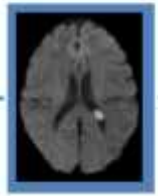
DIFFUSION

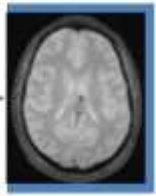
Proton density

Graident echo









Brain image

Skull is white

Skull is not white

CT

MRI

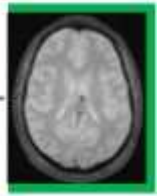
CSF

white

Black

Grey

Graident echo

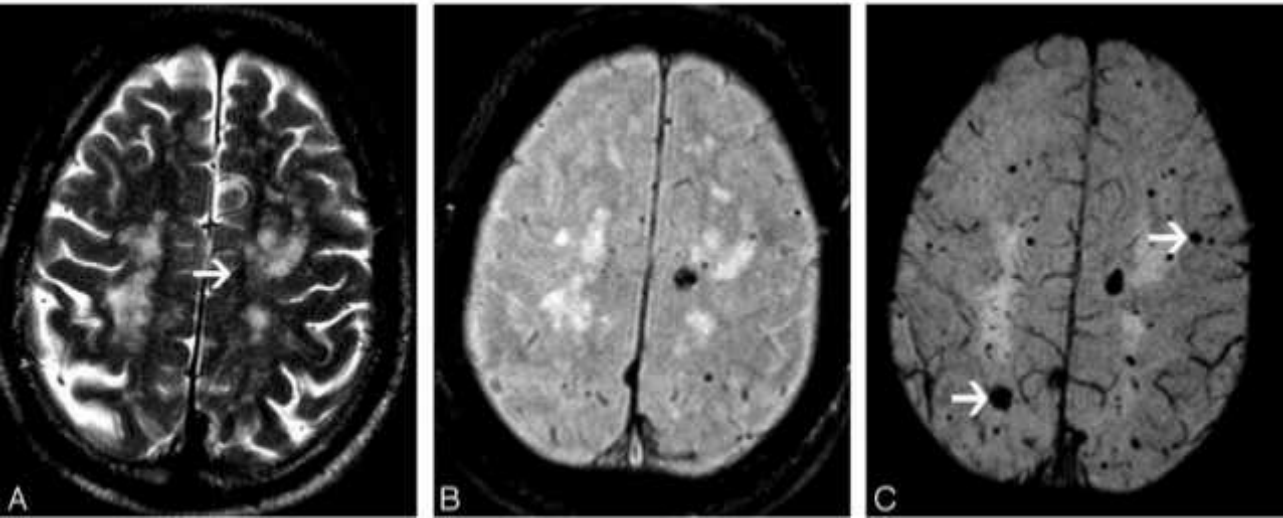


Gradient T2* WIS

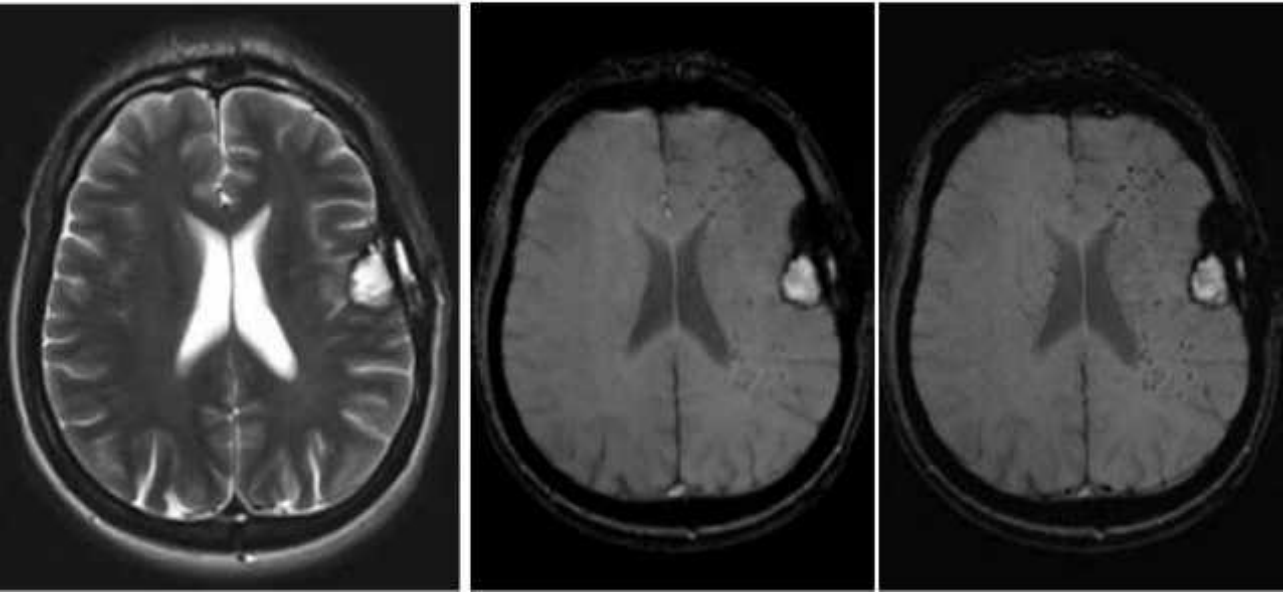
Sensitive to de-oxy hemoblobin and hemosiderin because of their susceptibility effects.

- Cavernous malformations.
- Amyloid angiopathy.
- Post-radiation capillary telangiectasia.

Cavernous malformations



Post-radiation capillary telangiectasia

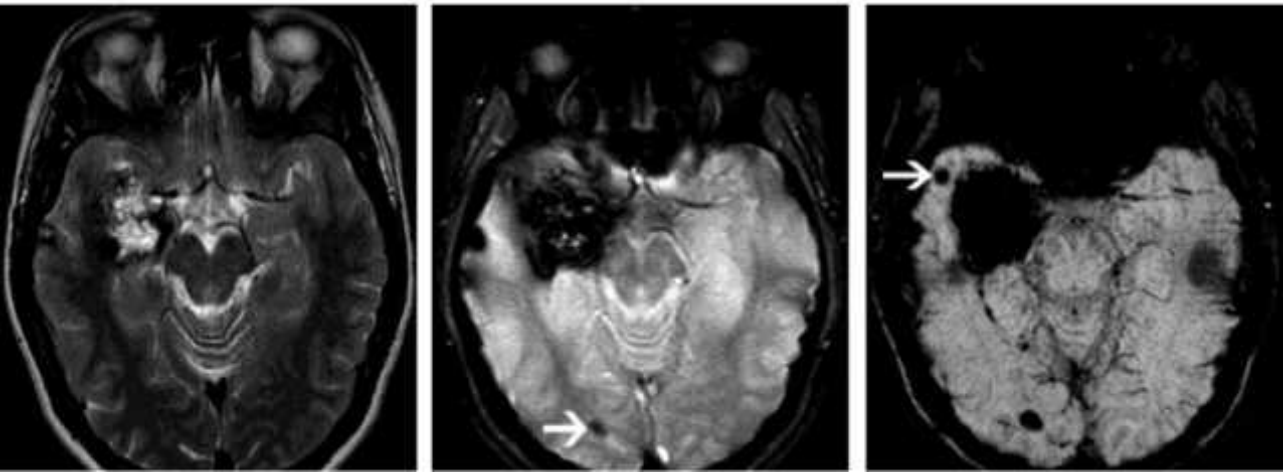


Disadvantages of Gradient T2WIs

- Blooming artifact.

Blooming artifact

- Obscure adjacent smaller lesions



Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

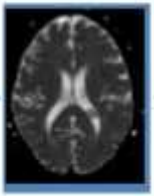
T1

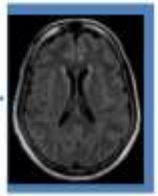
FLAIR

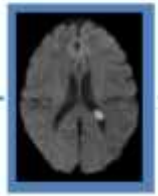
DIFFUSION

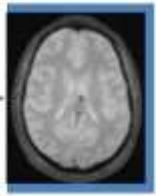
Proton density

Graident echo









Brain image

Skull is white

Skull is not white

CT

MRI

CSF

white

Black

Grey

T2

ADC

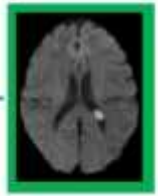
T1

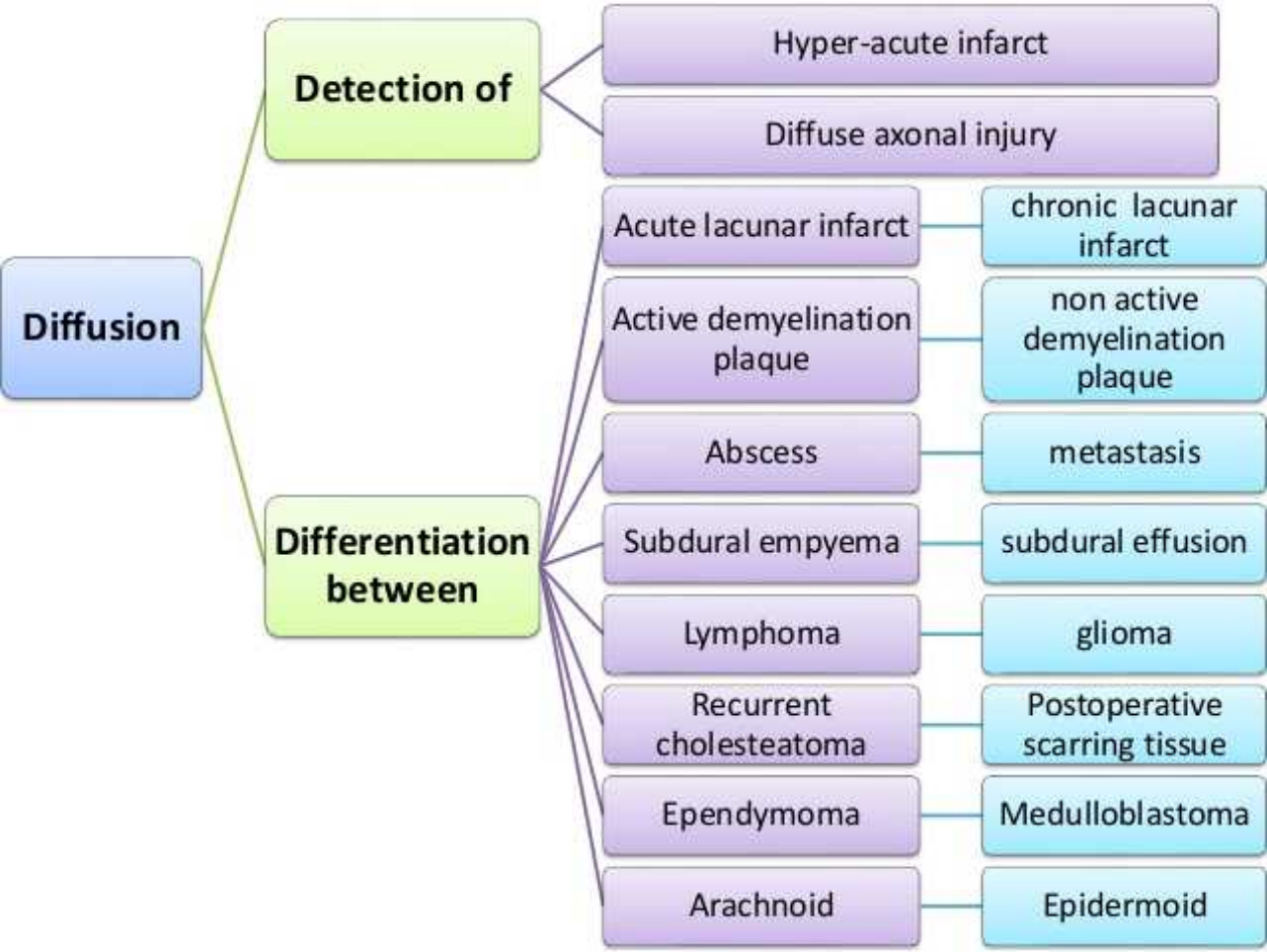
FLAIR

DIFFUSION

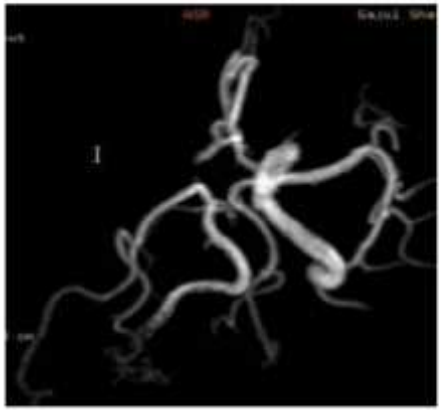
Proton density

Graident echo

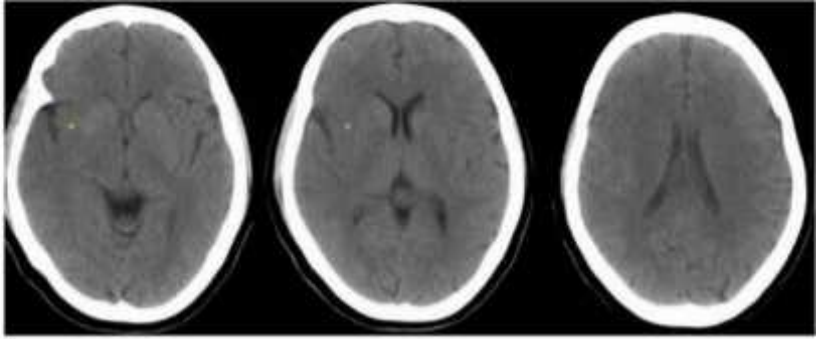


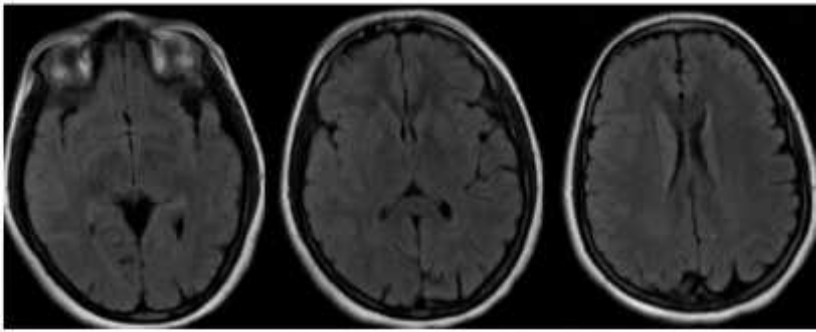

Diffusion
Detection of
Hyper-acute infarct
Diffuse axonal injury
Differentiation between
Acute lacunar infarct
chronic lacunar infarct
Active demyelination plaque
non active demyelination plaque
Abscess
metastasis
Subdural empyema
subdural effusion
Lymphoma
glioma
Recurrent cholesteatoma
Postoperative scarring tissue
Ependymoma
Medulloblastoma
Arachnoid
Epidermoid

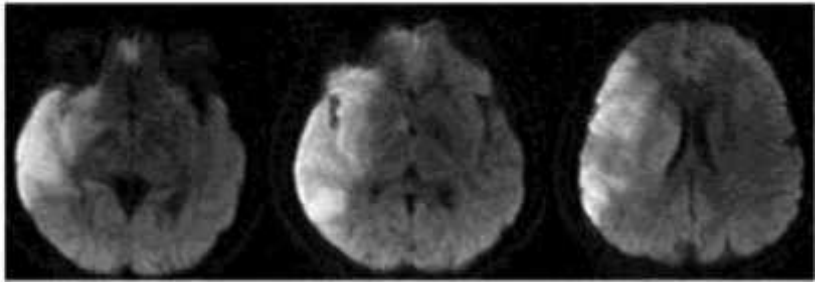
Hyper-acute stroke



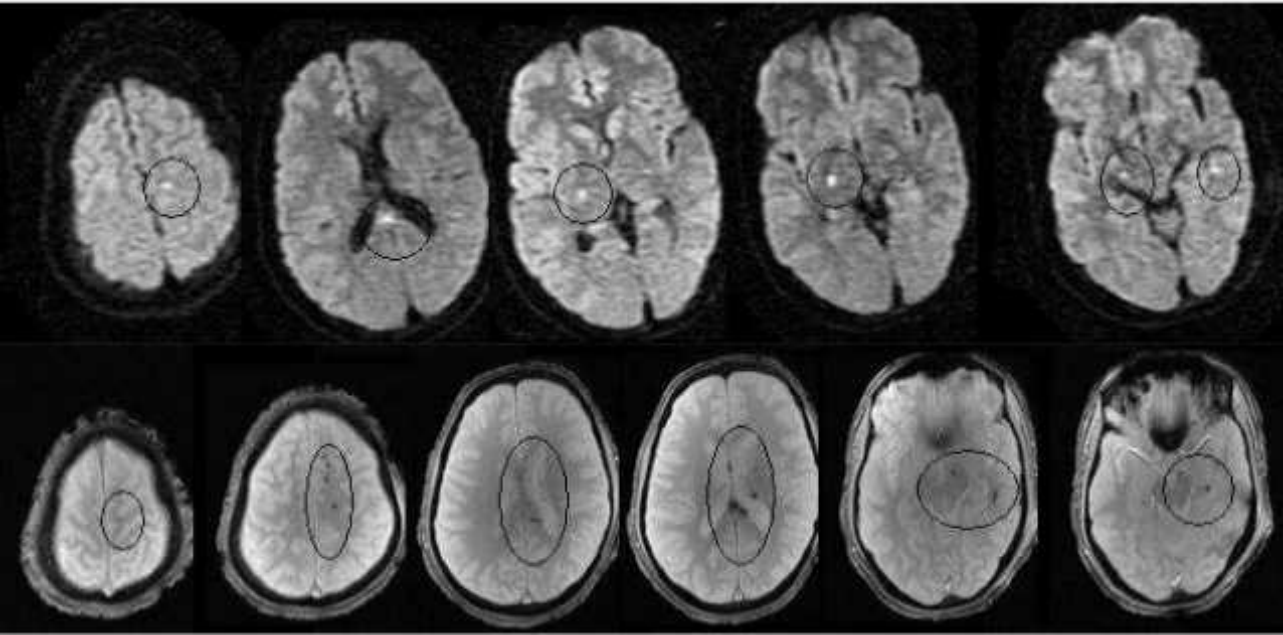
- FLAIR / Diffusion mismatch



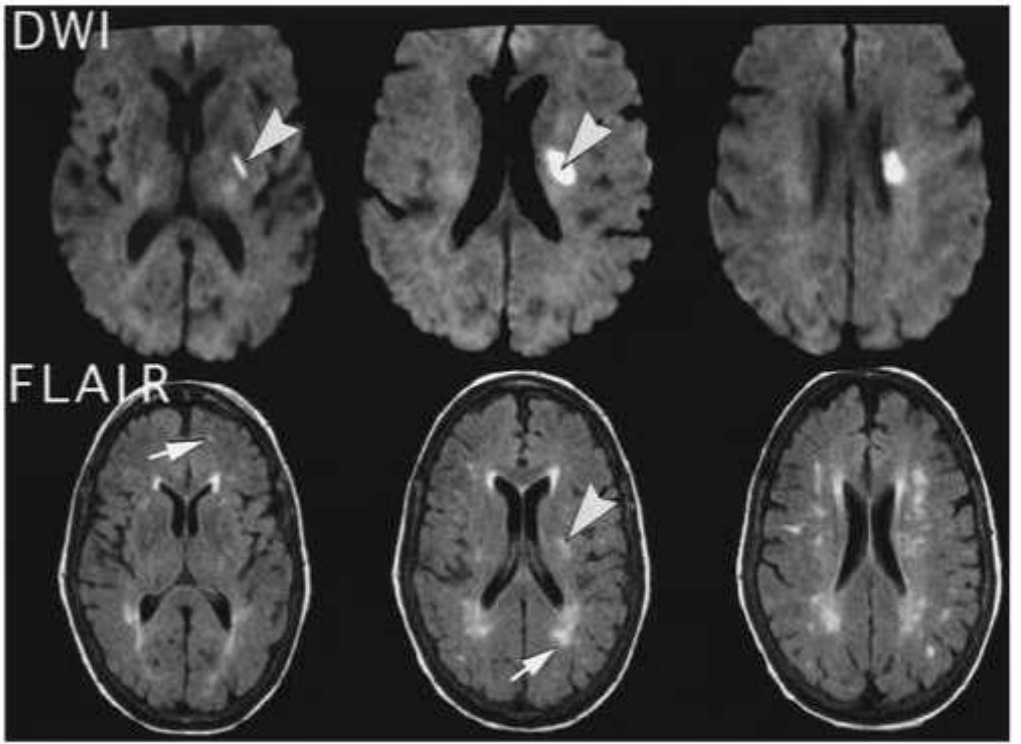




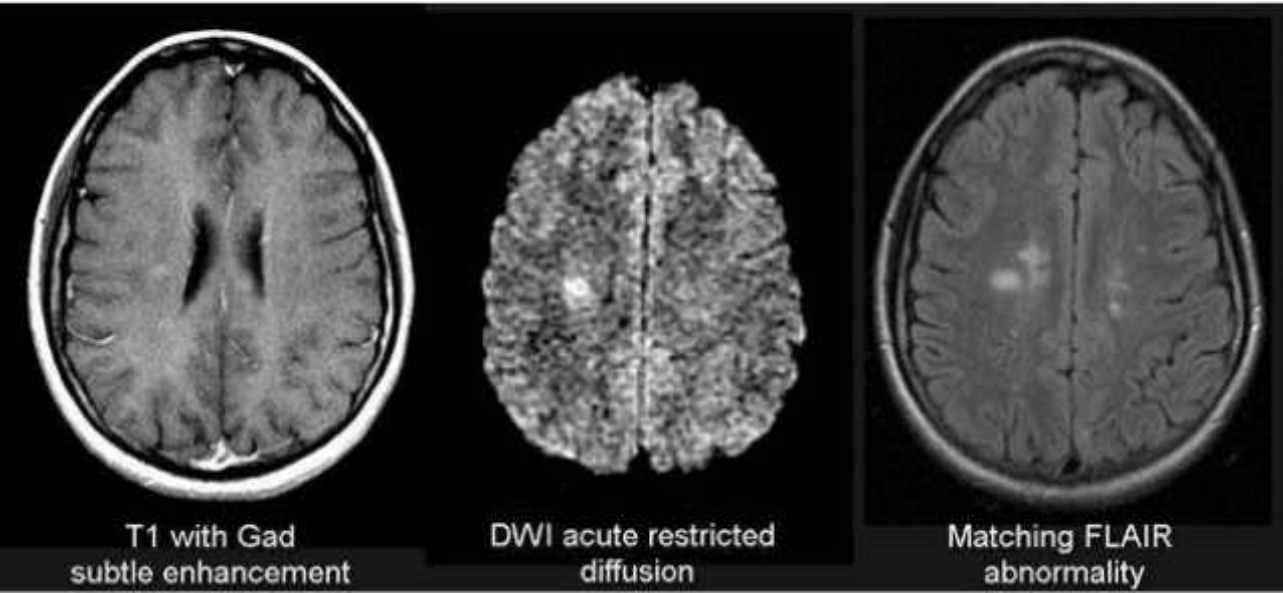
Diffuse axonal injury



Acute vs chronic lacunar infarcts

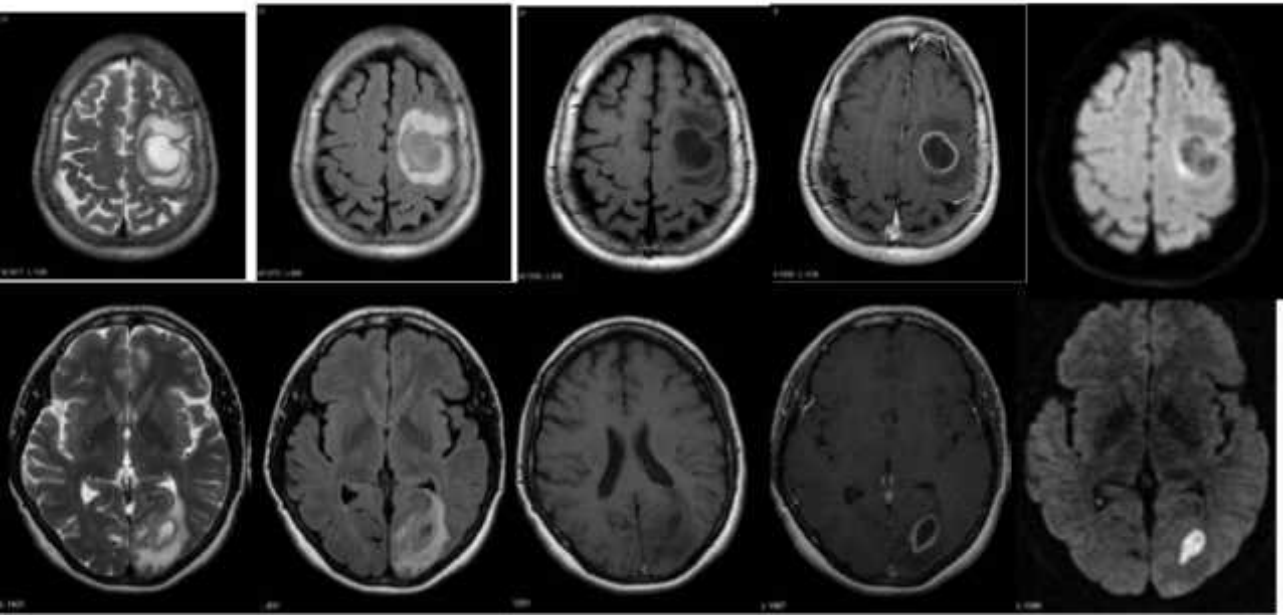


Active demyelination plaque

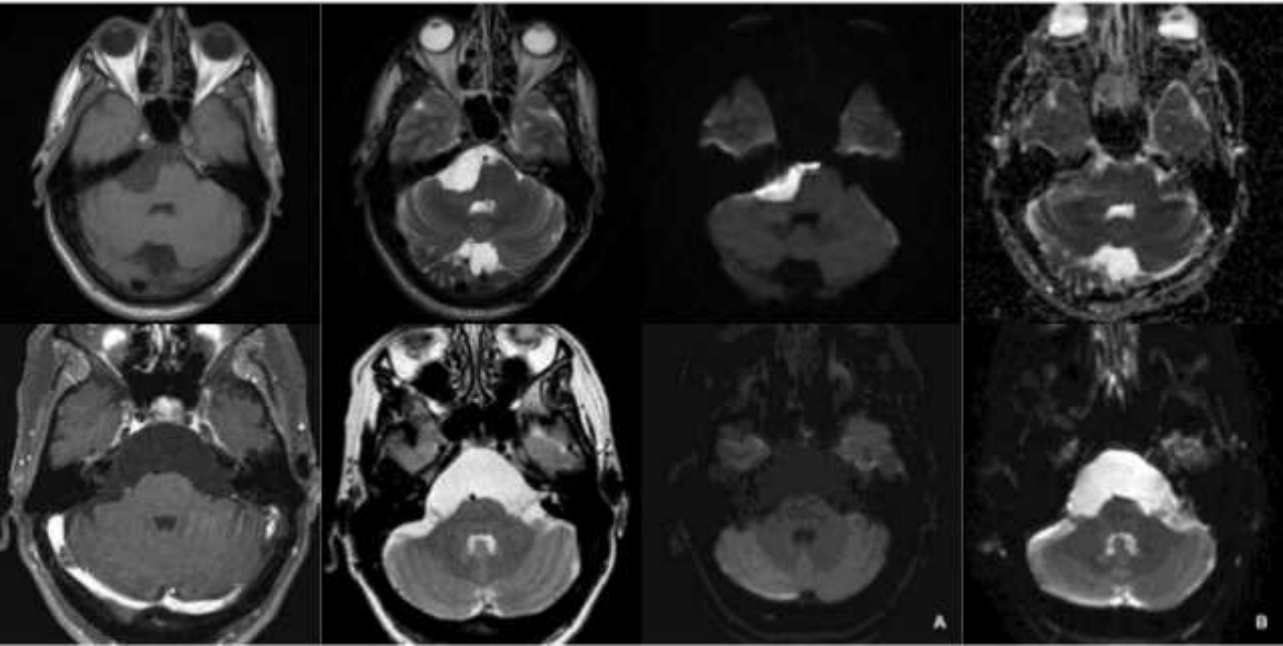


Abscess vs metastasis

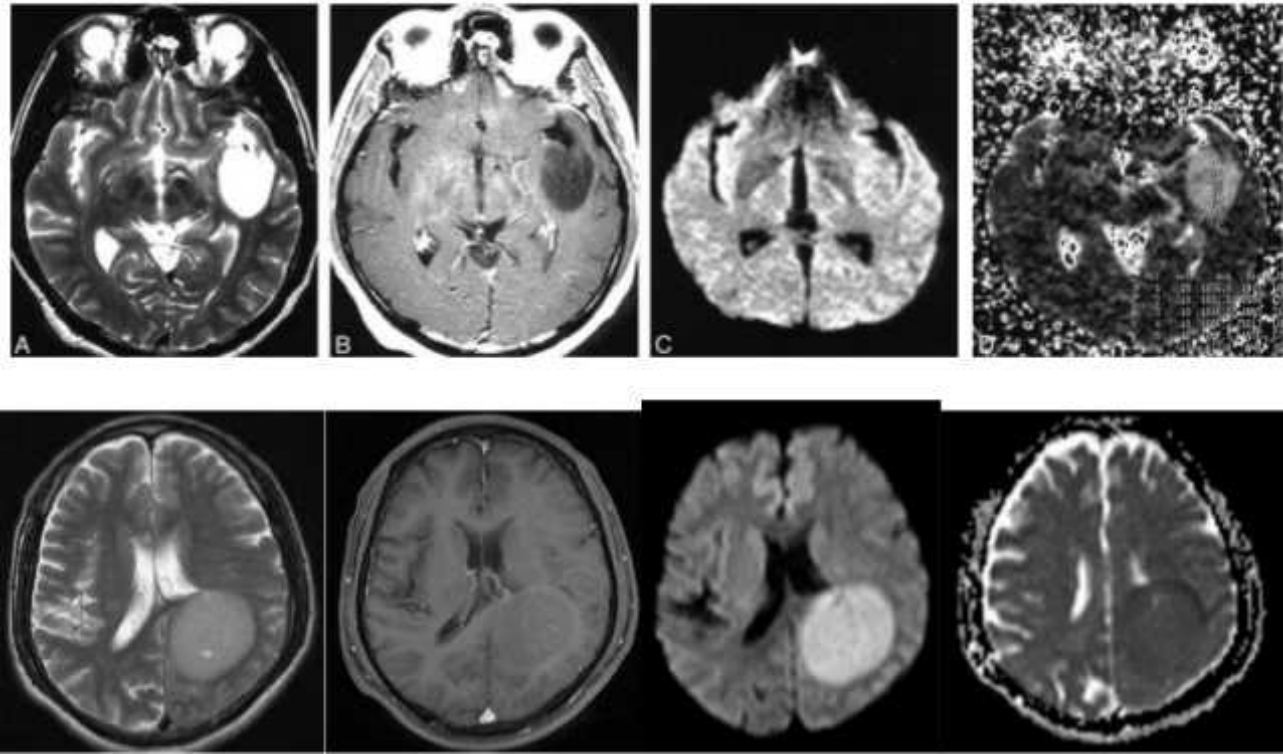
- High viscosity of pus → restricted diffusion



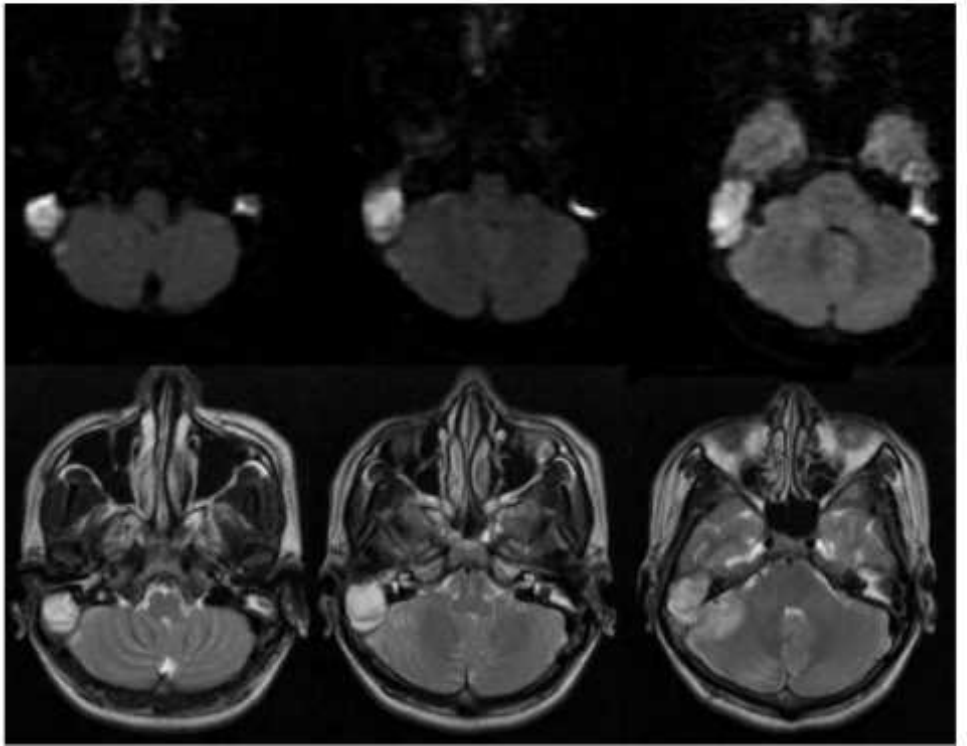
Arachnoid vs epidermoid



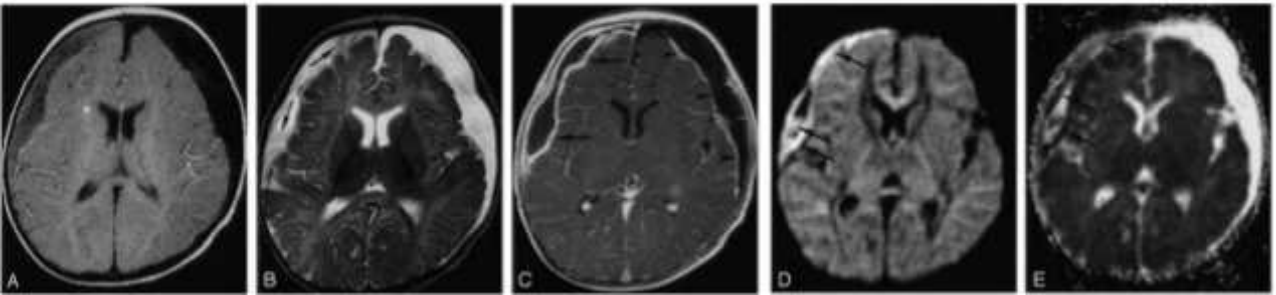
Glioma vs lymphoma



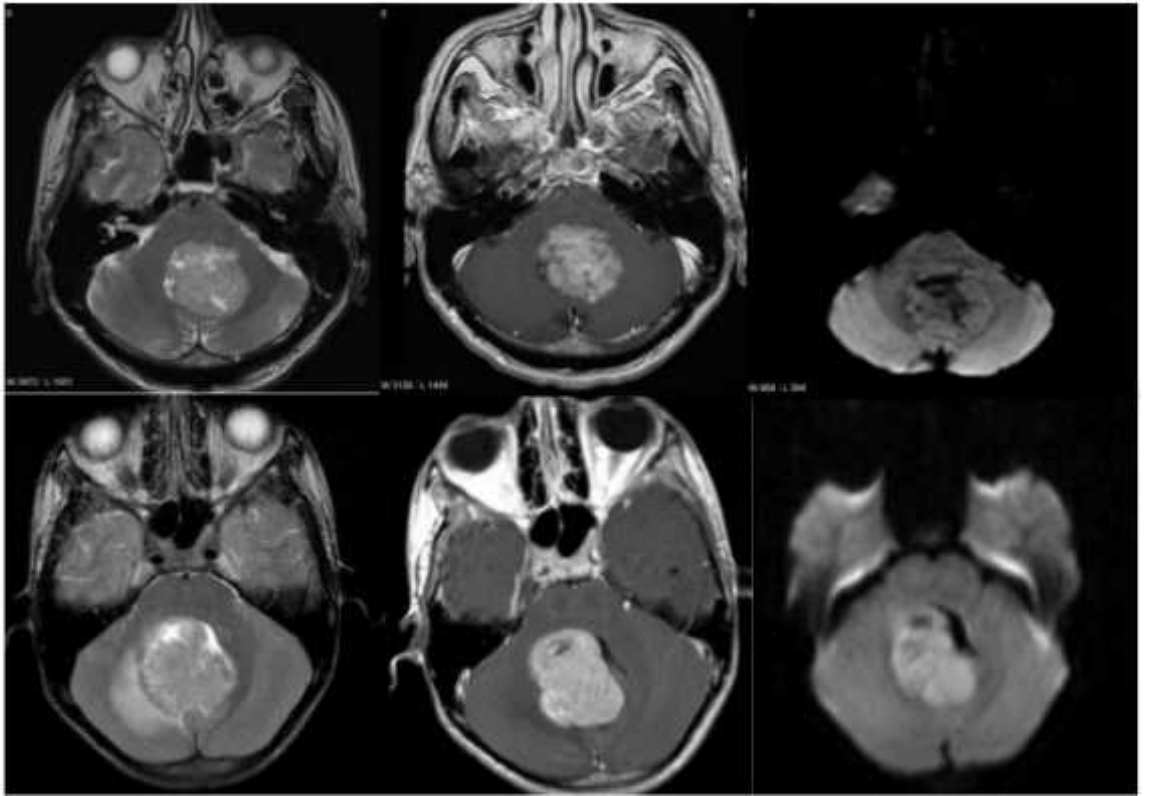
Recurrent cholesteatoma vs **post-operative scarring tissue**



Subdural **empyema** vs subdural **effusion**



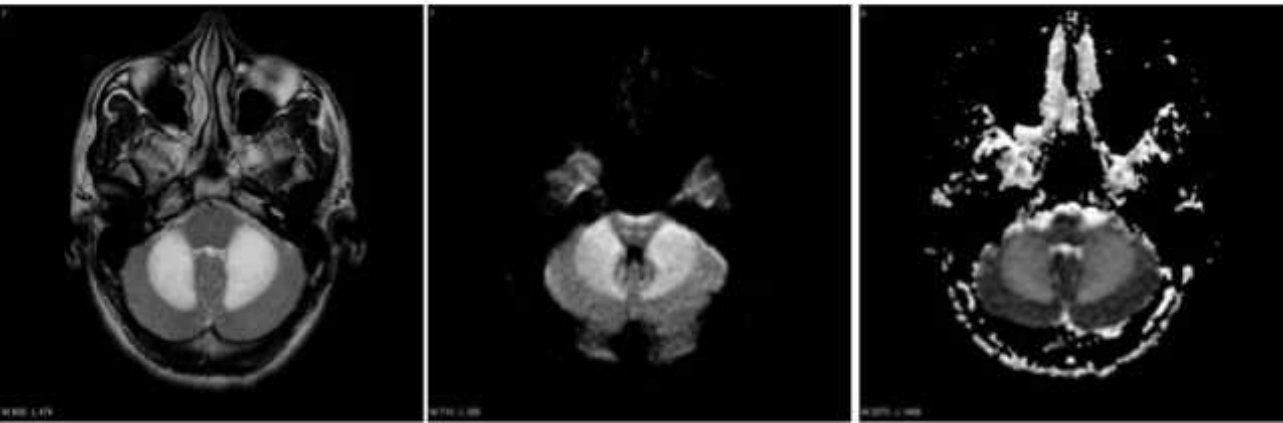
Ependymoma vs **medulloblastoma**



Diffusion artifacts

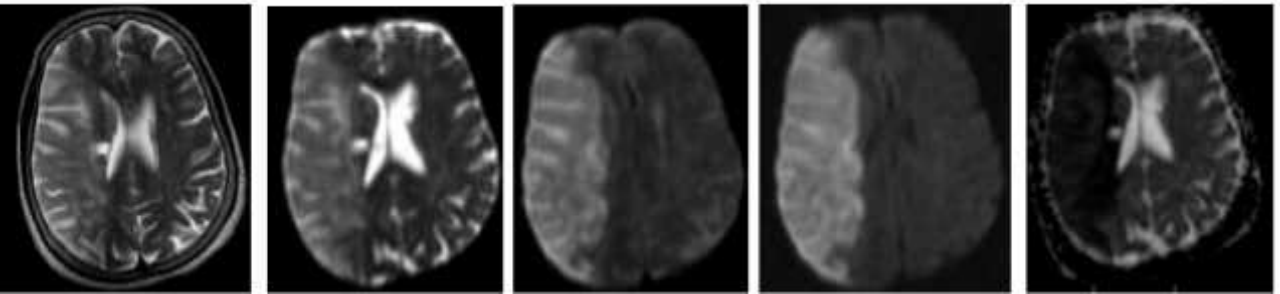
- T2 shine through effect.
- Anisotropic diffusion.

T2 Shine through artifact

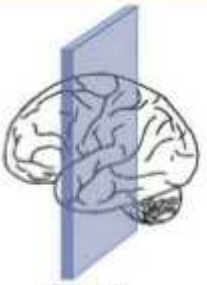


Restricted diffusion vs T2 shine through

T2	DWI	DWI	DWI	ADC
	• B0	• B500	• B1000	



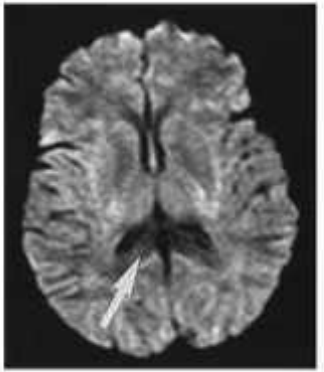
Anisotropic diffusion



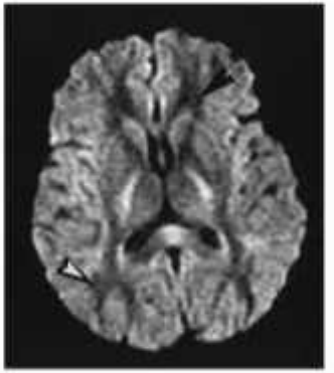
Coronal

Axial

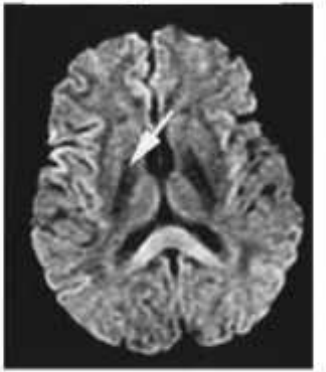
Sagittal



Gx



Gy



Gz

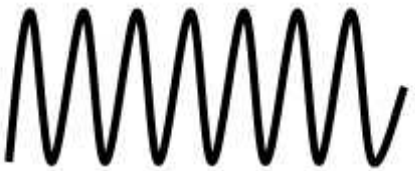
Advanced MRI techniques

- MR spectroscopy.
- MR perfusion.
- DTI
- Tractography.

What is MRS?

- It is an MRI technique whereby the echo that is obtained from the body is analyzed into its various *radio-frequency* components rather than making an *image*.

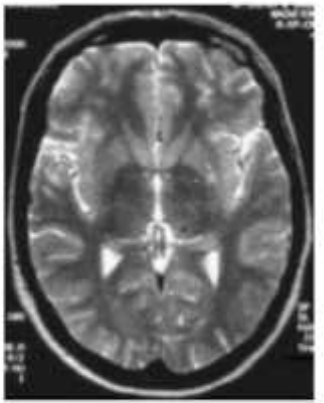
Echo Analysis

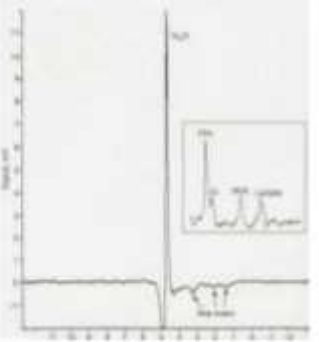


ECHO

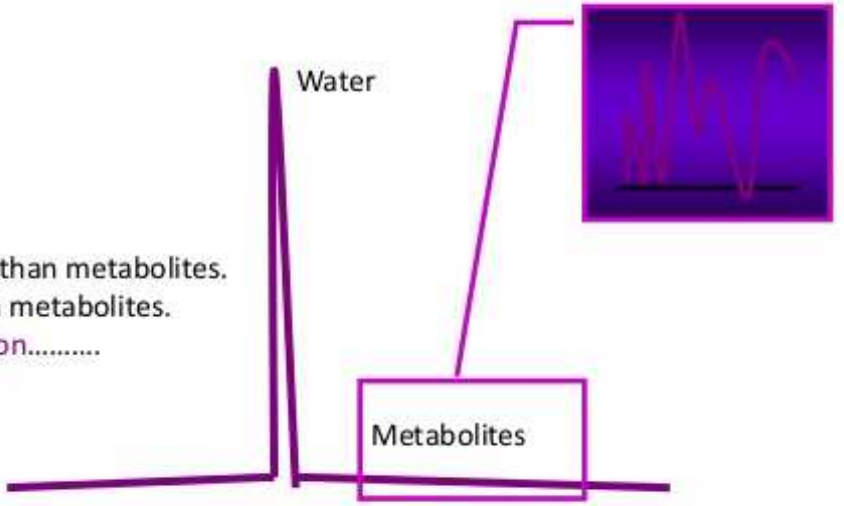
MRI

MRS





Suppression Techniques



- Water is 100,000 X than metabolites.
- Fat is 10,000 X than metabolites.

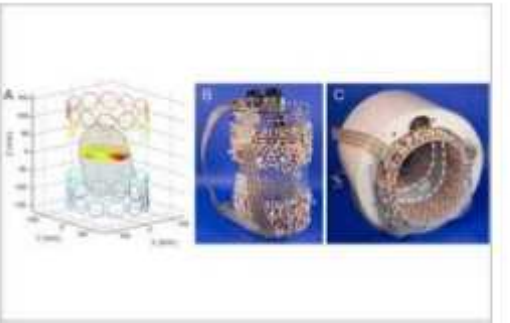
.....need suppression.....

CHESS = Chemical Shift Suppression.
WEFT = Water Elimination Fourier Transform Tech.

I.R Pulses to null water signal prior to spectroscopy

Requirements

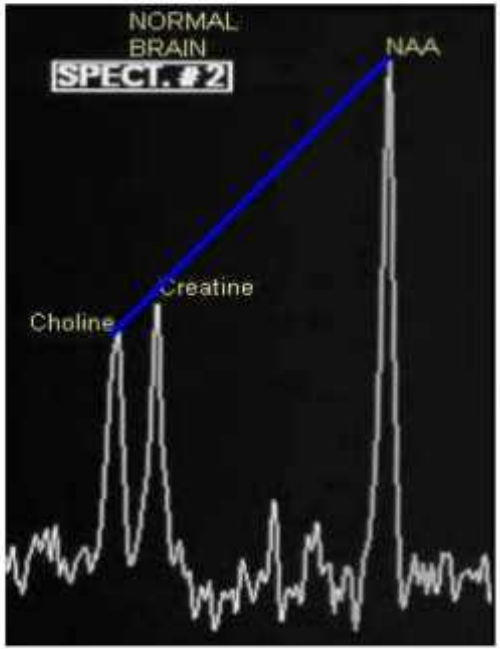
- **High Field.**
  - **1.5 T & 3T.**
- **High Homogeneity**
  - **Less than 0.2 p.p.m**
  - **Assessed by measuring the water peak width.**



Metabolites

- NAA: Neuronal marker. (2.0 ppm)
  - Neuronal marker
  - Any neuronal loss.....decrease NAA.
- Choline: Cell membrane. (3.2 ppm)

  High cellularity & membrane turn-over...increase Choline.
- Creatine: energy marker. (3.0 ppm)

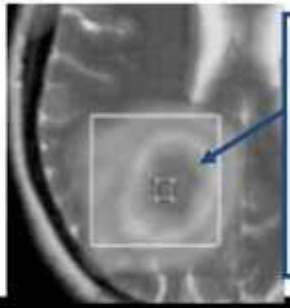


Metabolites

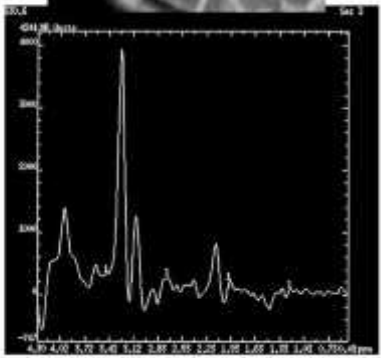
- Lactate: Cell death. (1.3 ppm)
  - Necrosis & hypoxia (anaerobic glycolysis) …increase Lactate.
- Lipid: (1.3-1.5 ppm)
  - Necrosis
- Myo-Inositol: (3.5 ppm)
  - Decreases in High grade malignancy

Single vs. Multi-Voxel Spectroscopy

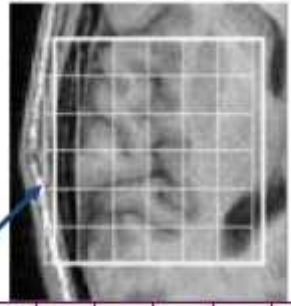
Single Voxel



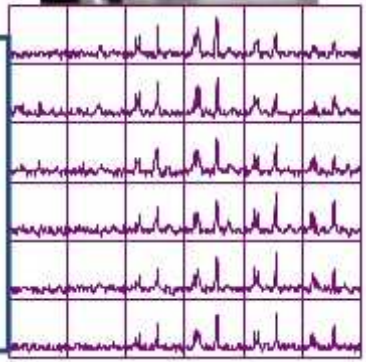
- 2X2X2 cm cube
- Short TE (STEAM)
  - TE=30-35 msec
- All Metabolites
- Lesion = 60-80%



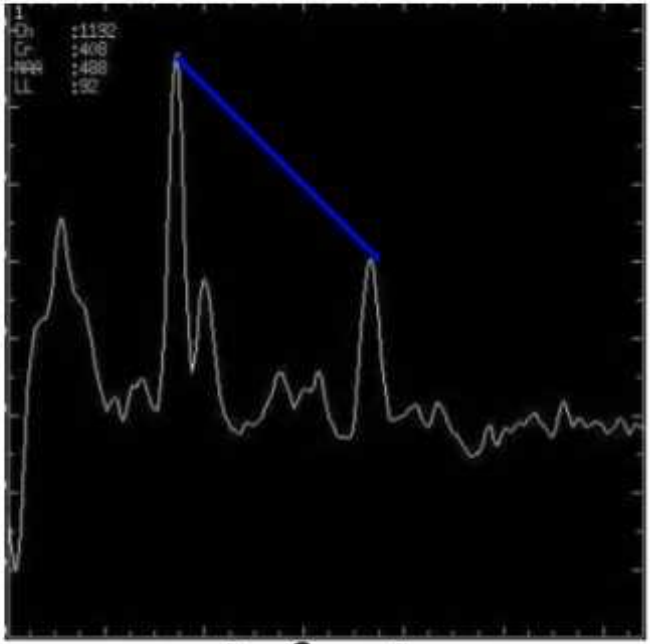
Multi Voxel



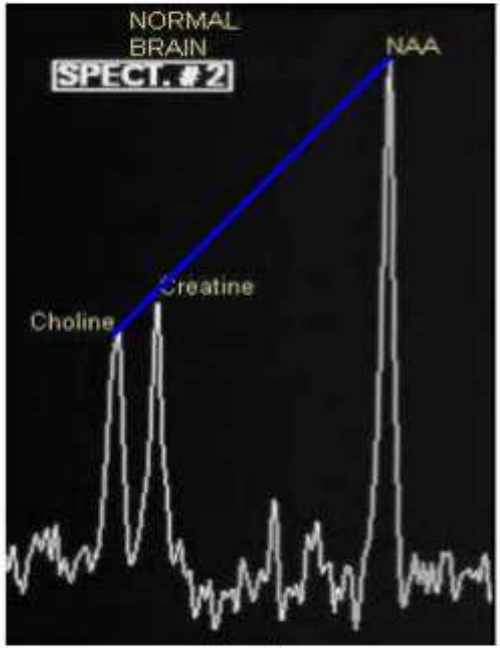
- 2X2X2 cm cube
- 2-3mm inner cubes
- Long TE (PRESS)
  - TE=135-260 msec
- Major Metabolites
- Margin outline



MRS

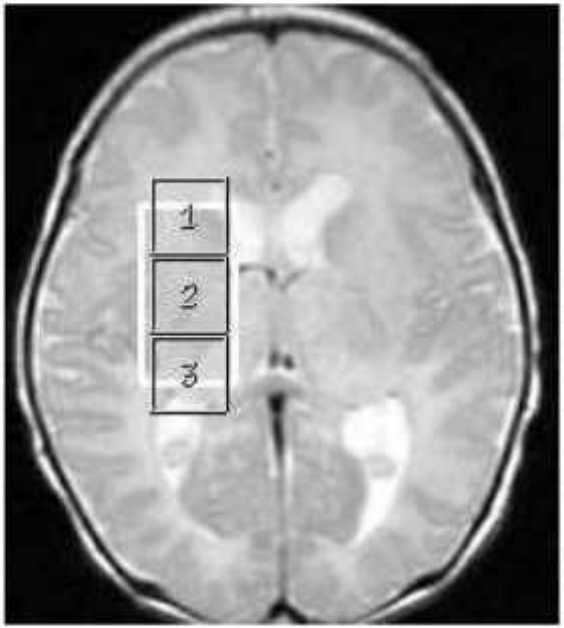


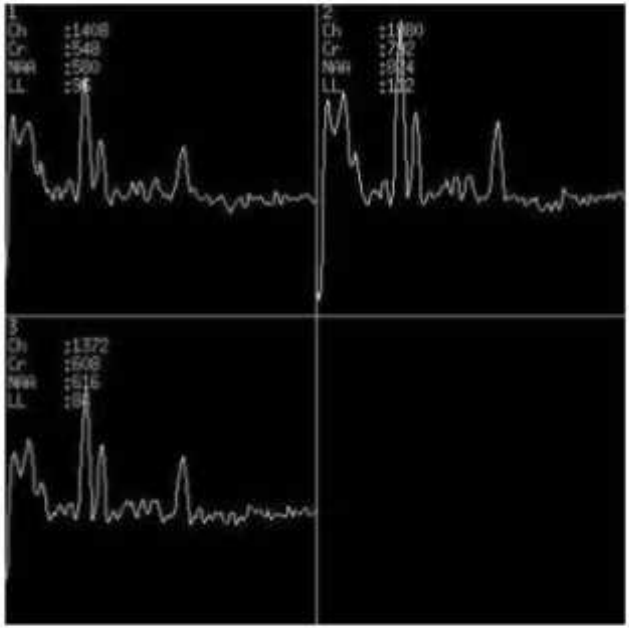
Infant



Adult

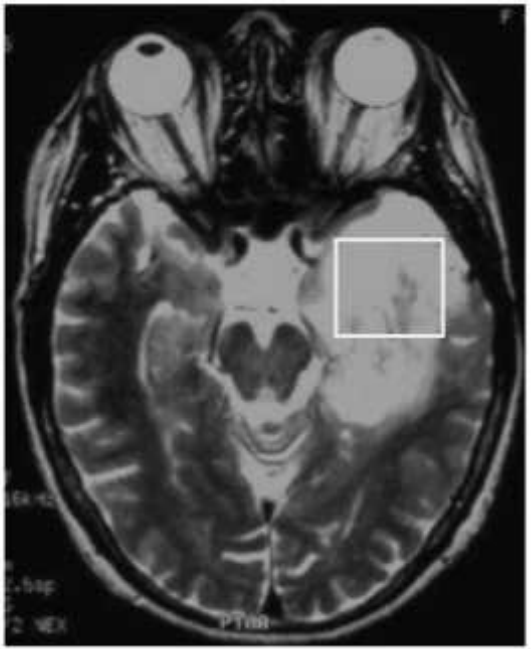
MRS for 6 days

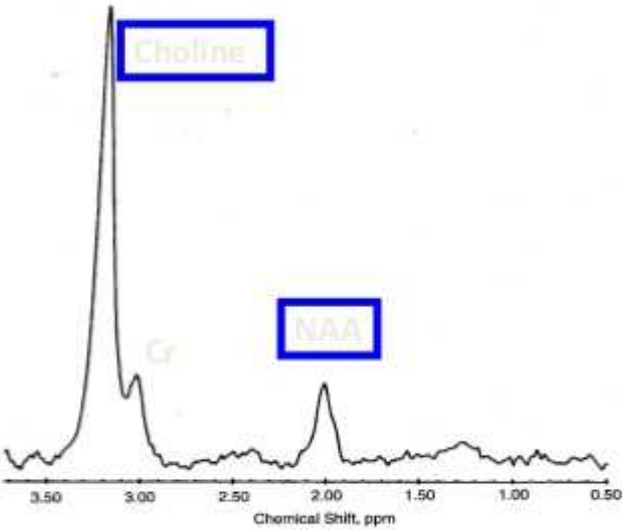


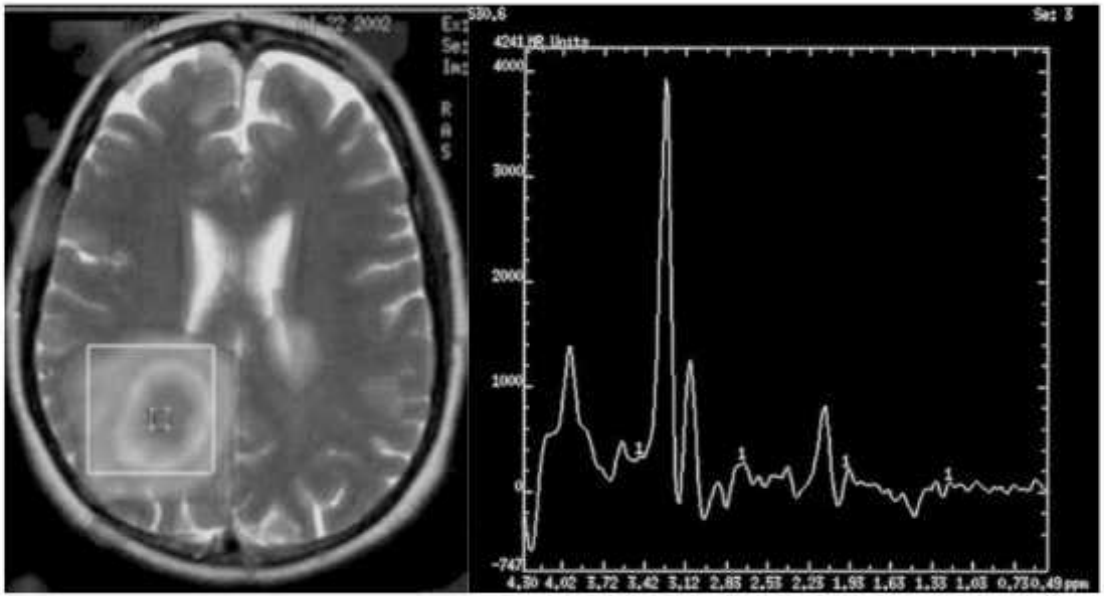


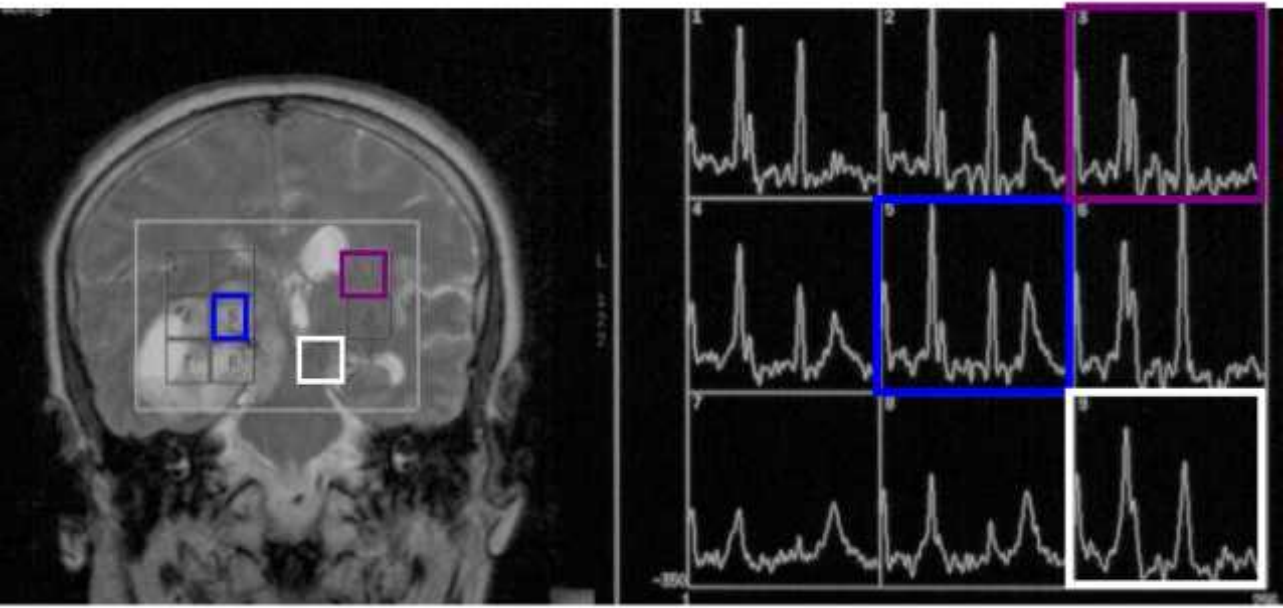
Tumour

- Increased Choline
- Increased Cho:Cr



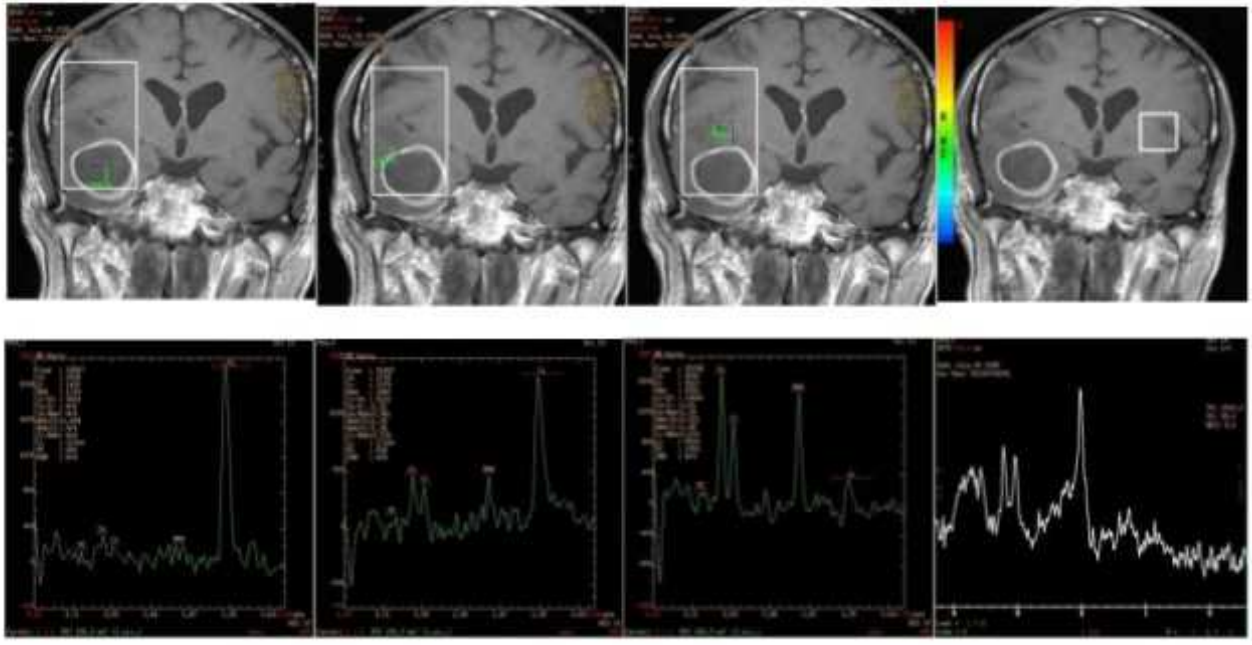



R
A
S
530.6
Se: 8
4241.98 Units
4000
3000
2000
1000
0
-747
4.30 4.02 3.72 3.42 3.12 2.83 2.53 2.23 1.93 1.63 1.33 1.03 0.73 0.49 ppm



Multi-voxel allows comparison with normal tissue.

MRS of an abscess

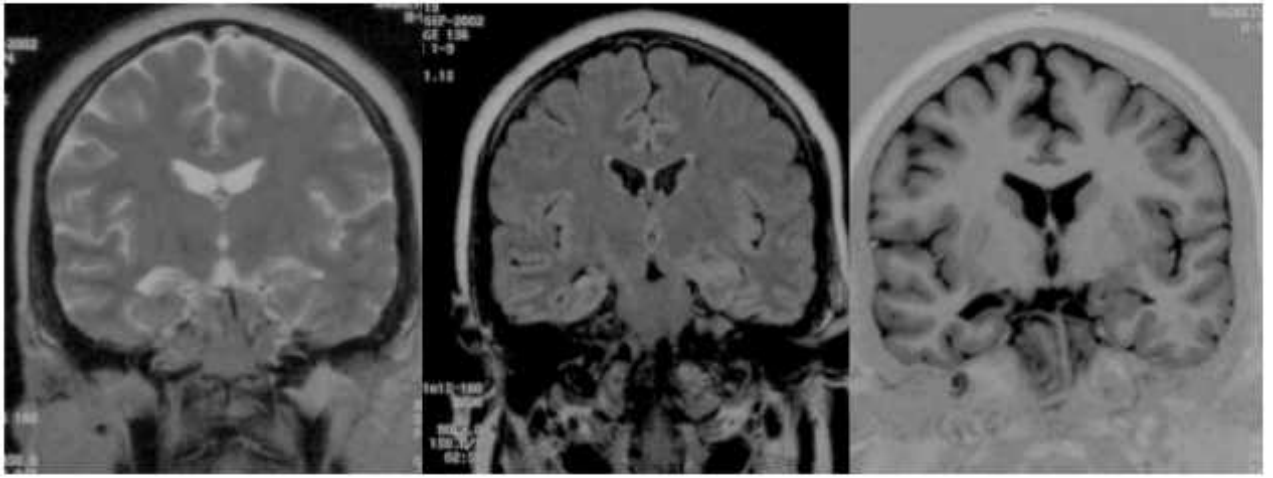


MRS

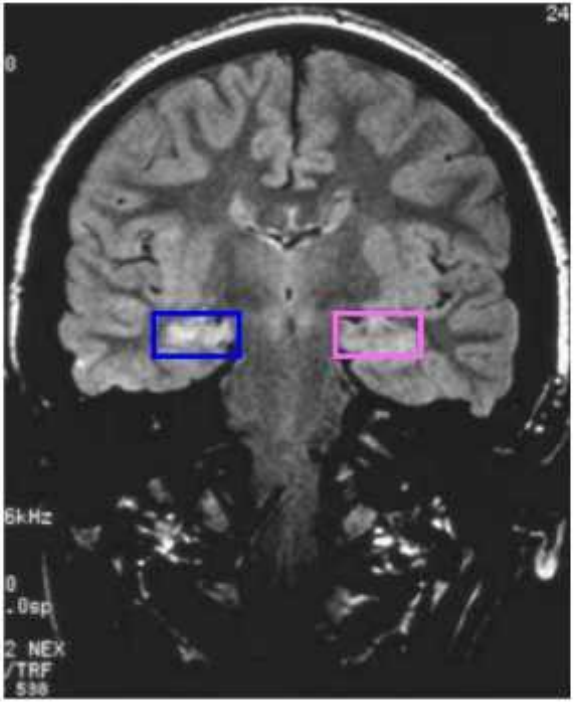
- Apart from Tumors, Necrosis and Infections

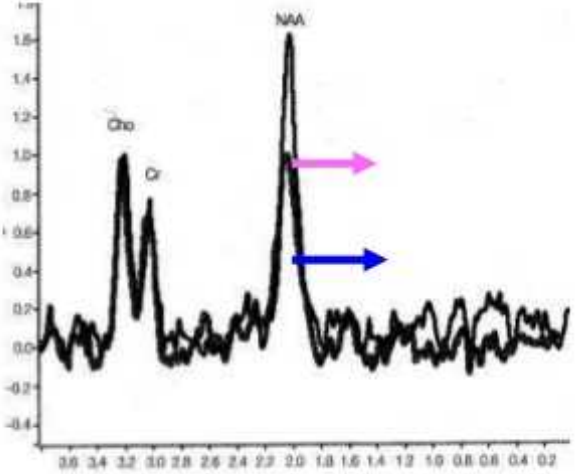
ARE THERE ANY OTHER APPLICATIONS FOR MRS?

TLE

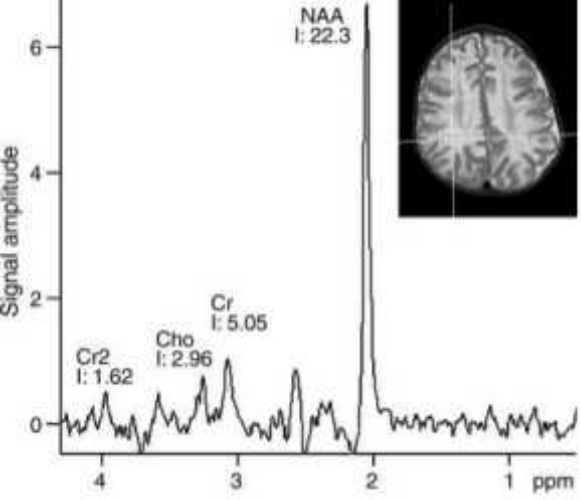


TLE

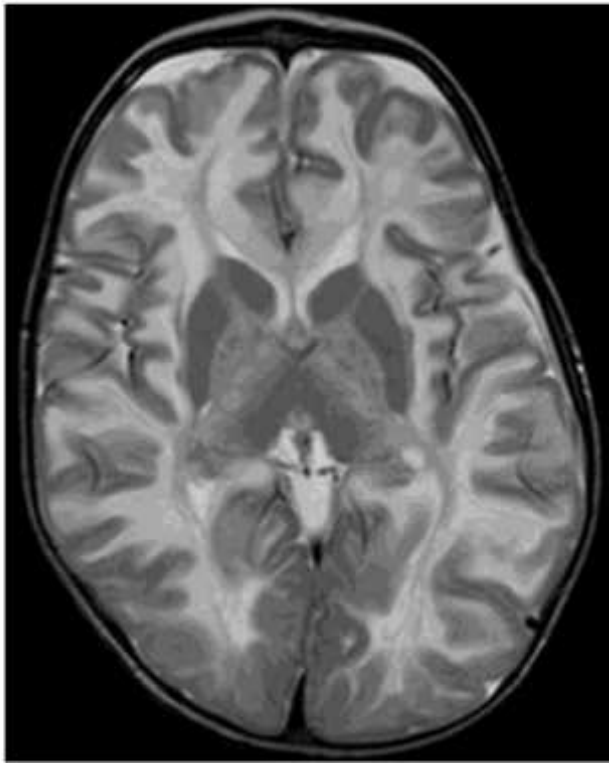




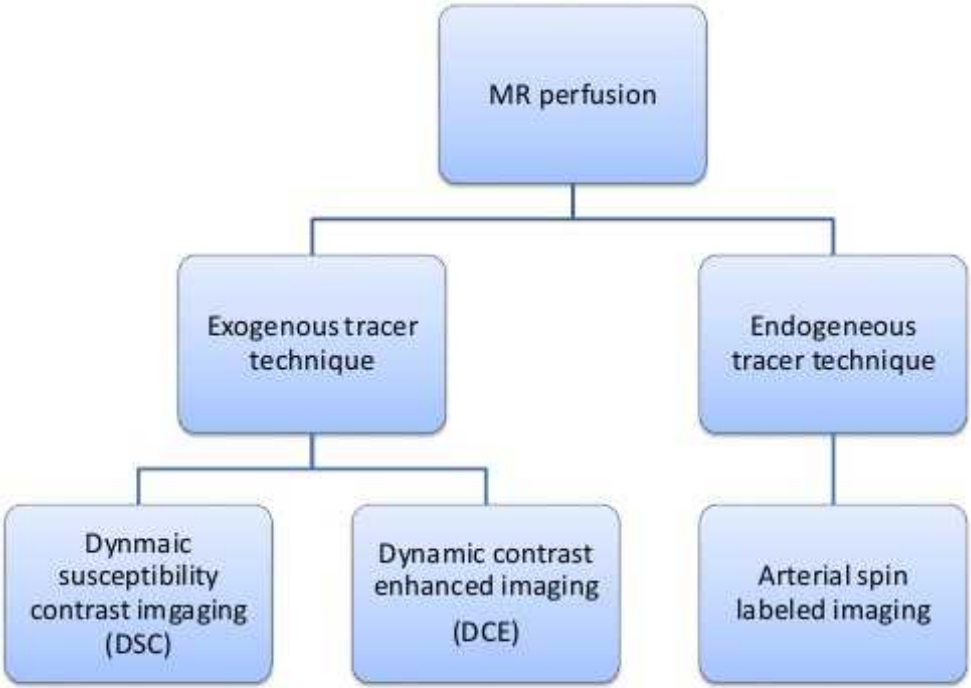
- Lateralization:
  - Decrease NAA
  - Increased Choline (15%)

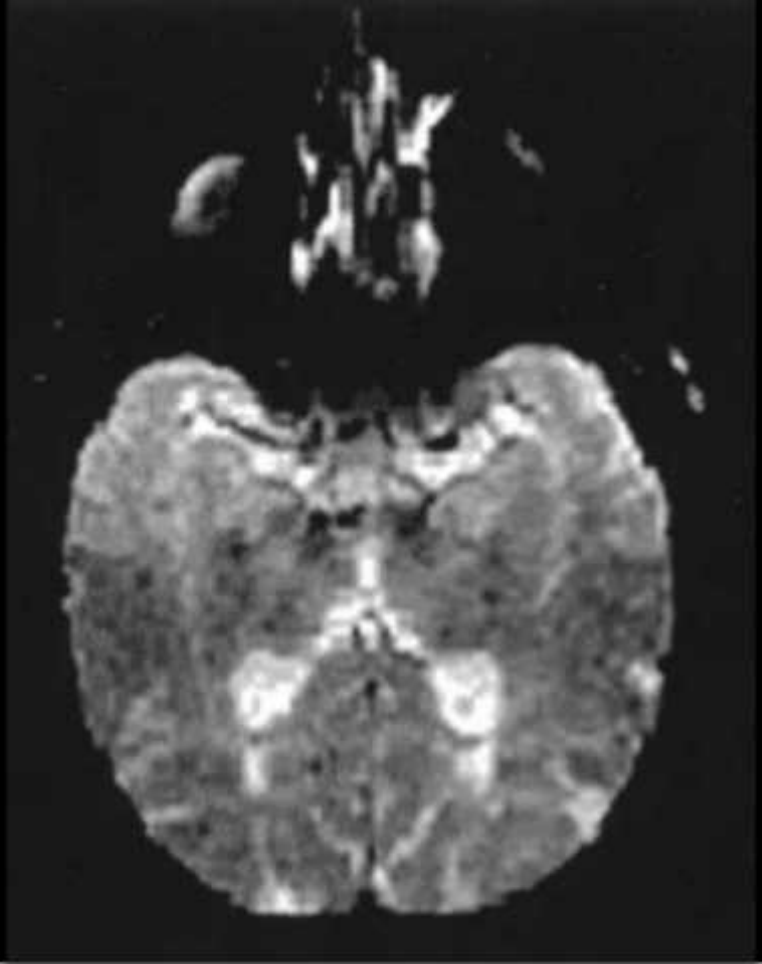


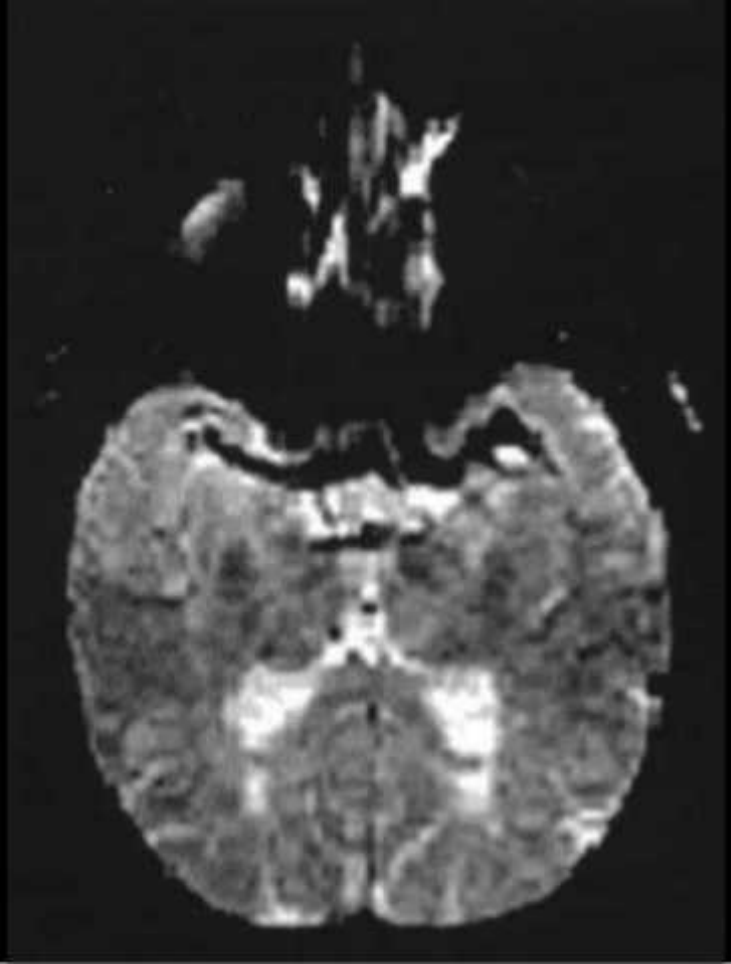
Canavan disease

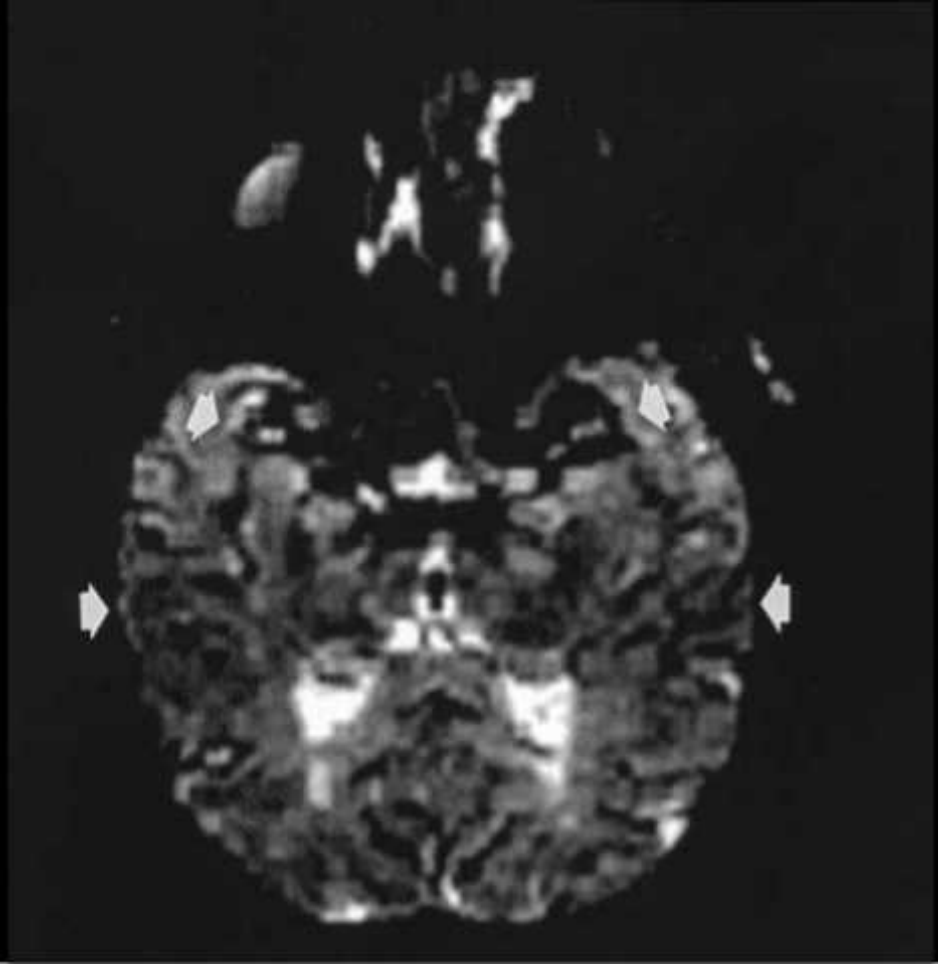


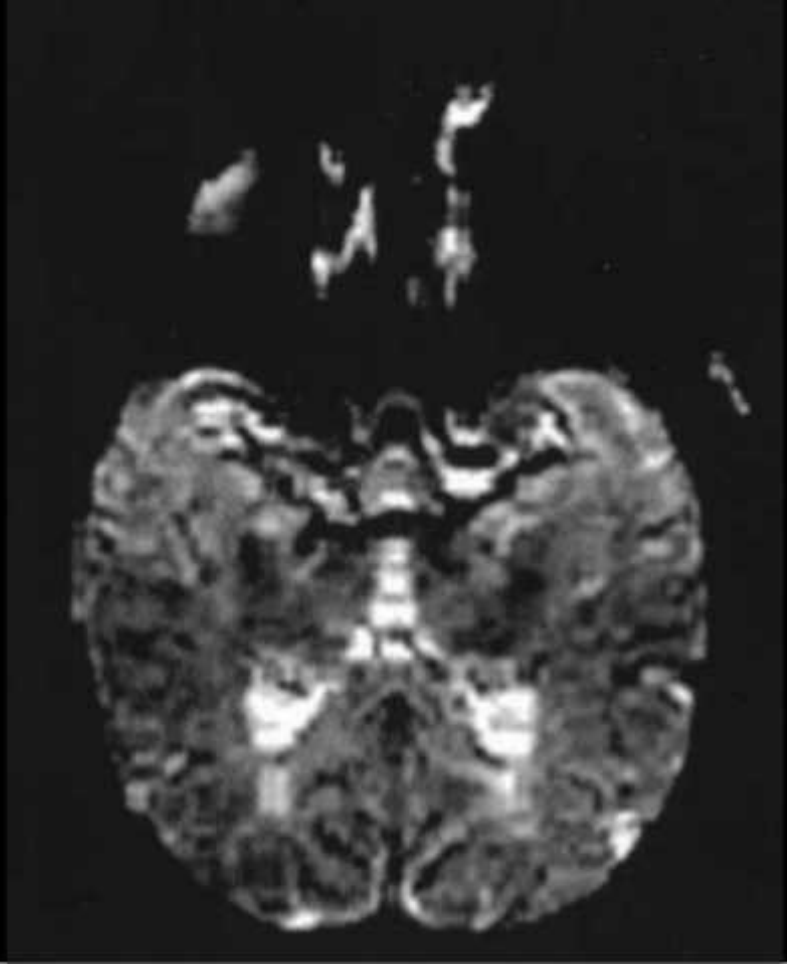
MR perfusion

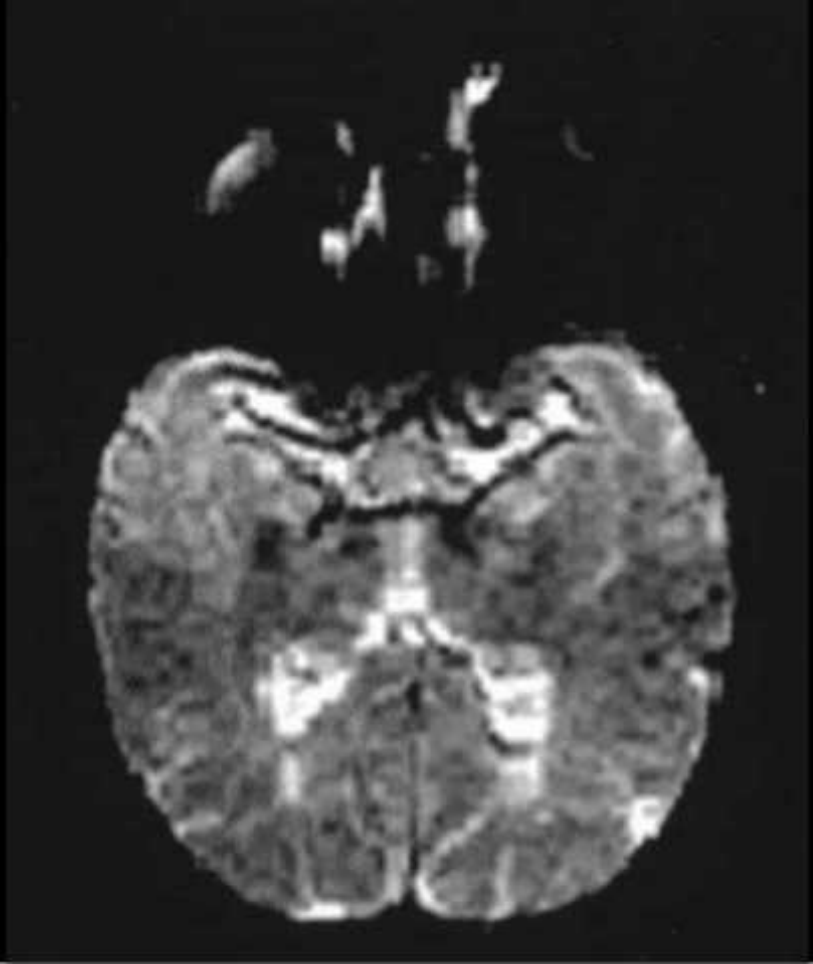








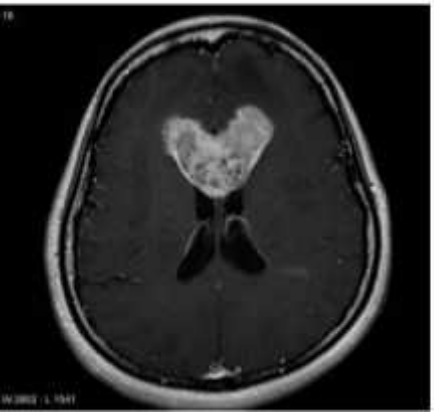


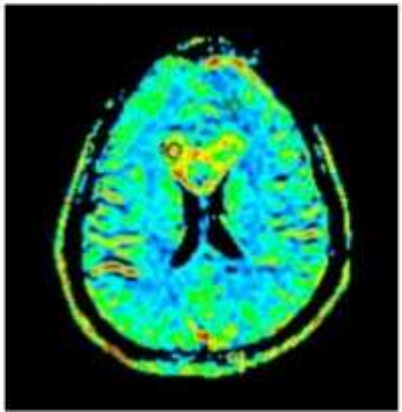


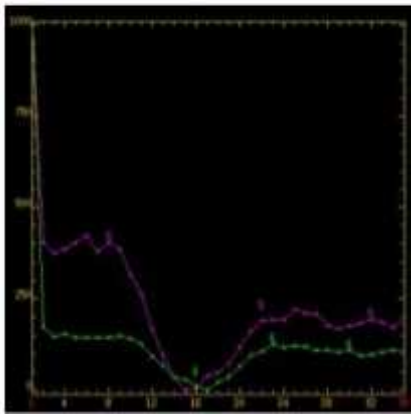
MR perfusion

CBV color map

Time signal intensity curve



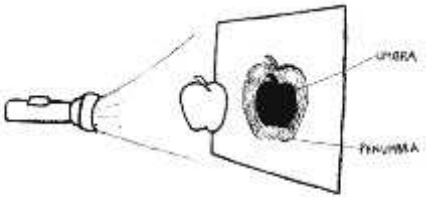




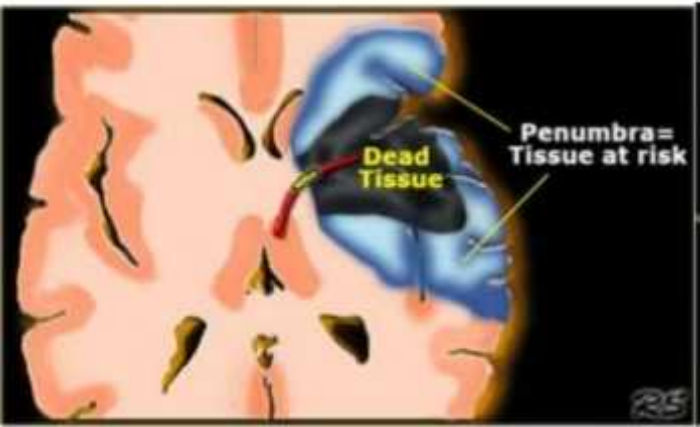
MR perfusion

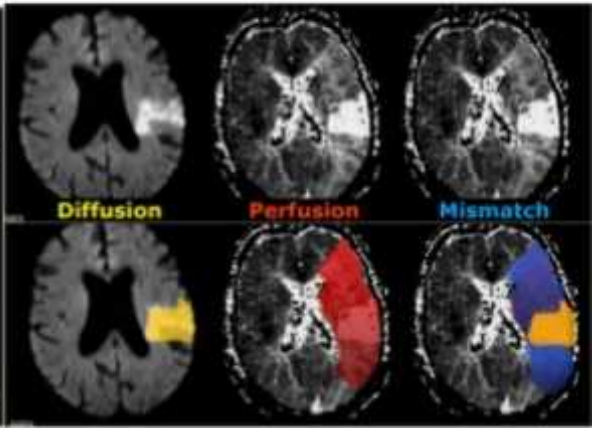
Value	Defined as	Measured in
Cerebral blood volume	Volume of blood in a given region of brain tissue	milliliters per 100 g of brain tissue
Cerbral blood flow	Volume of blood per unit time passing through a given region of brain tissue	milliliter per minute per 100 g of brain tissue
Mean transit time	Average time it takes blood to pass through a given region of brain tissue	Seconds

Stroke penumbra

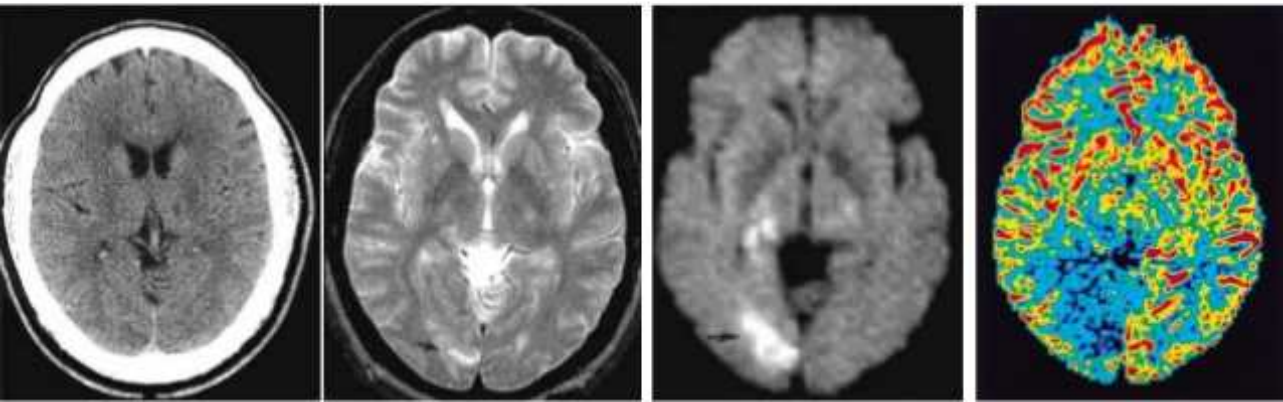


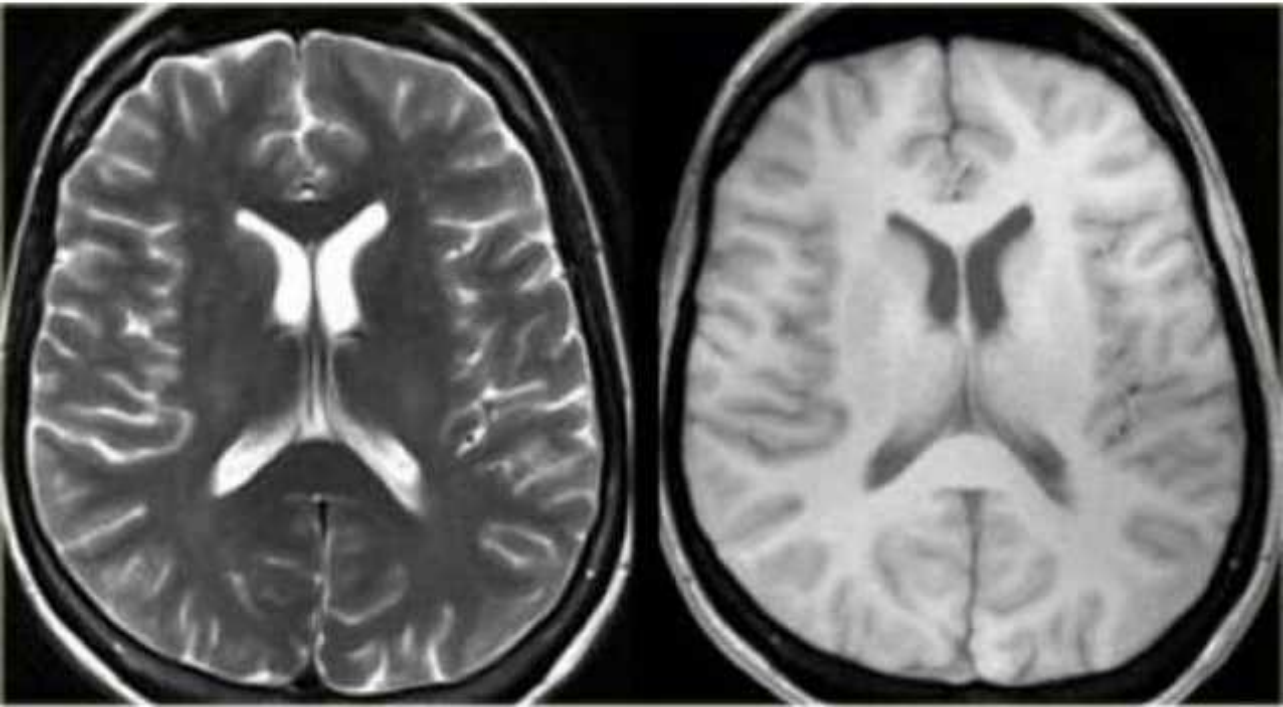
- Penumbra = perfusion / diffusion mismatch → thrombolytic therapy



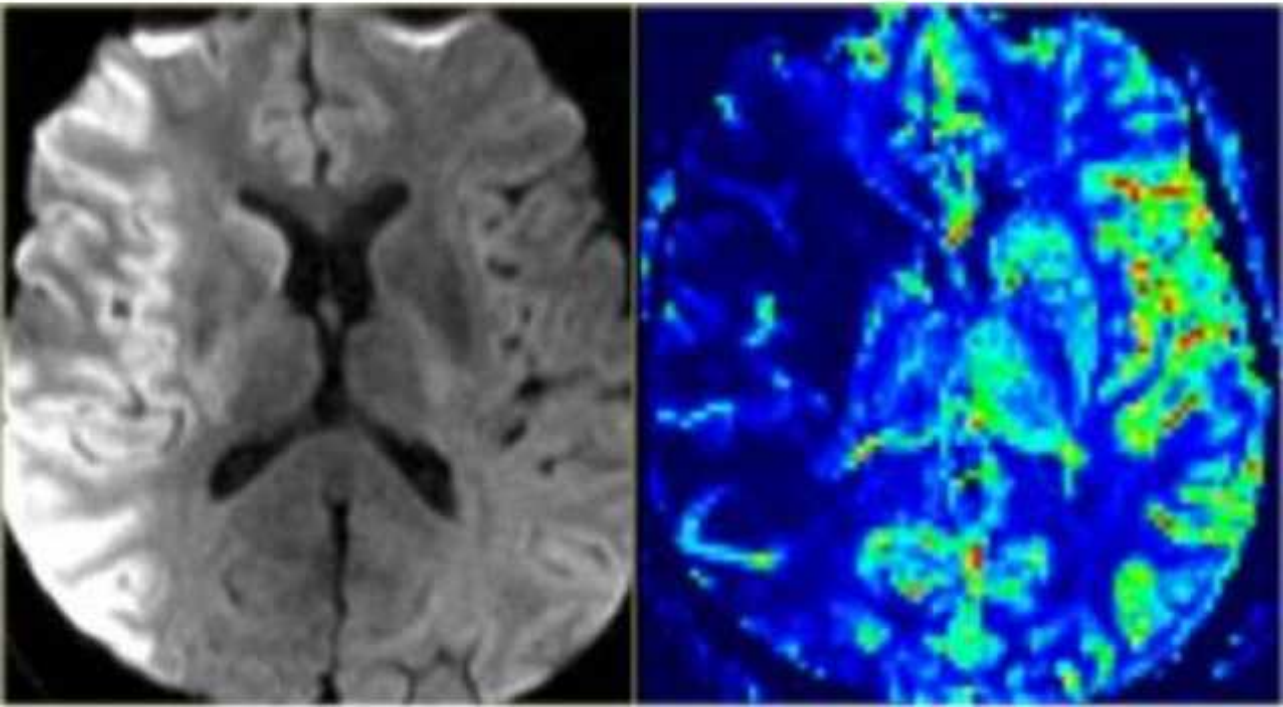


Diffusion/perfusion mismatch

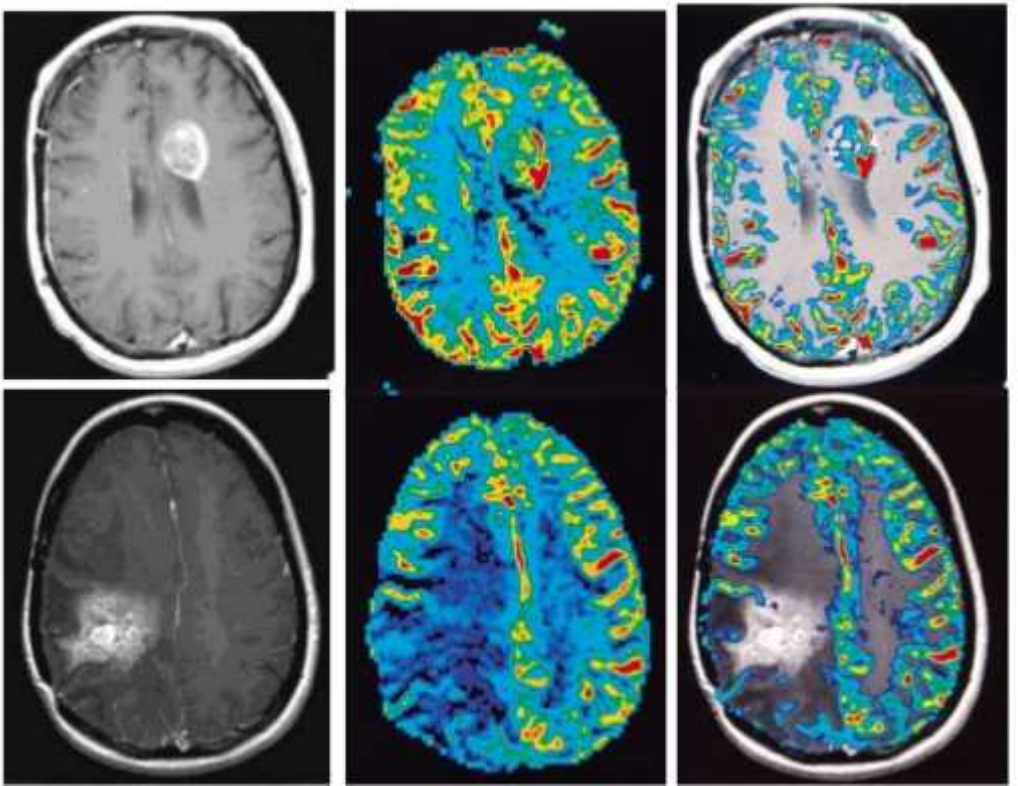




Diffusion/perfusion match

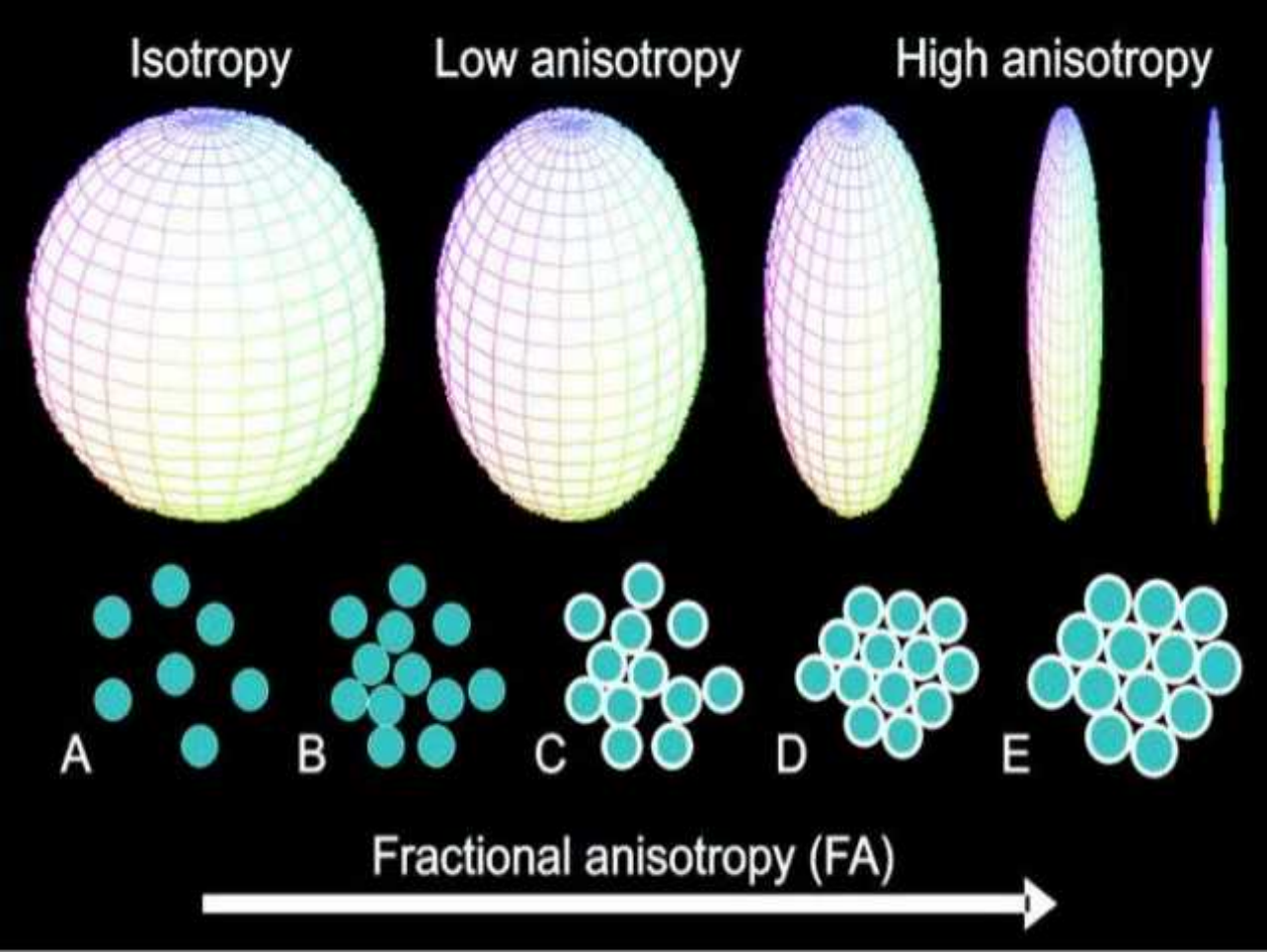


Post-radiation necrosis vs recurrent neoplasm

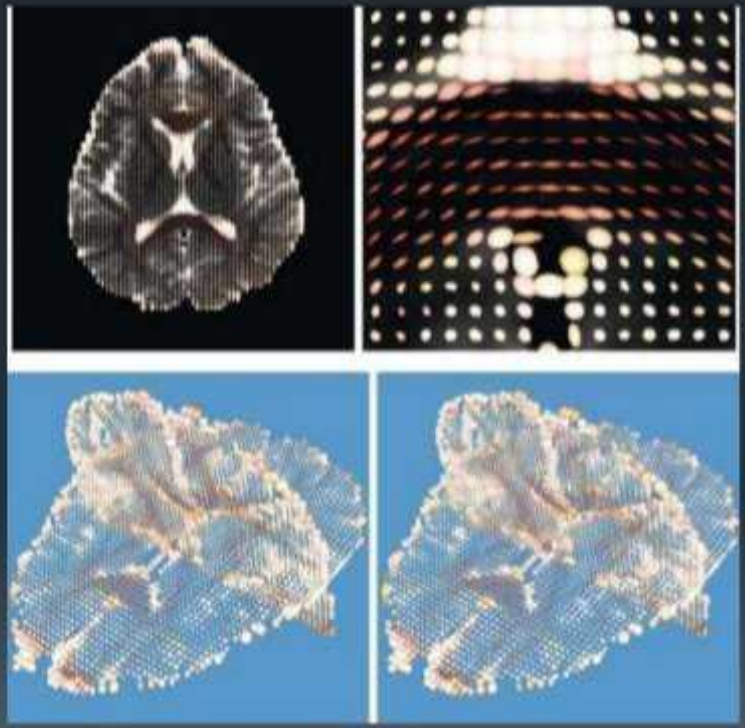


Diffusion tensor imaging

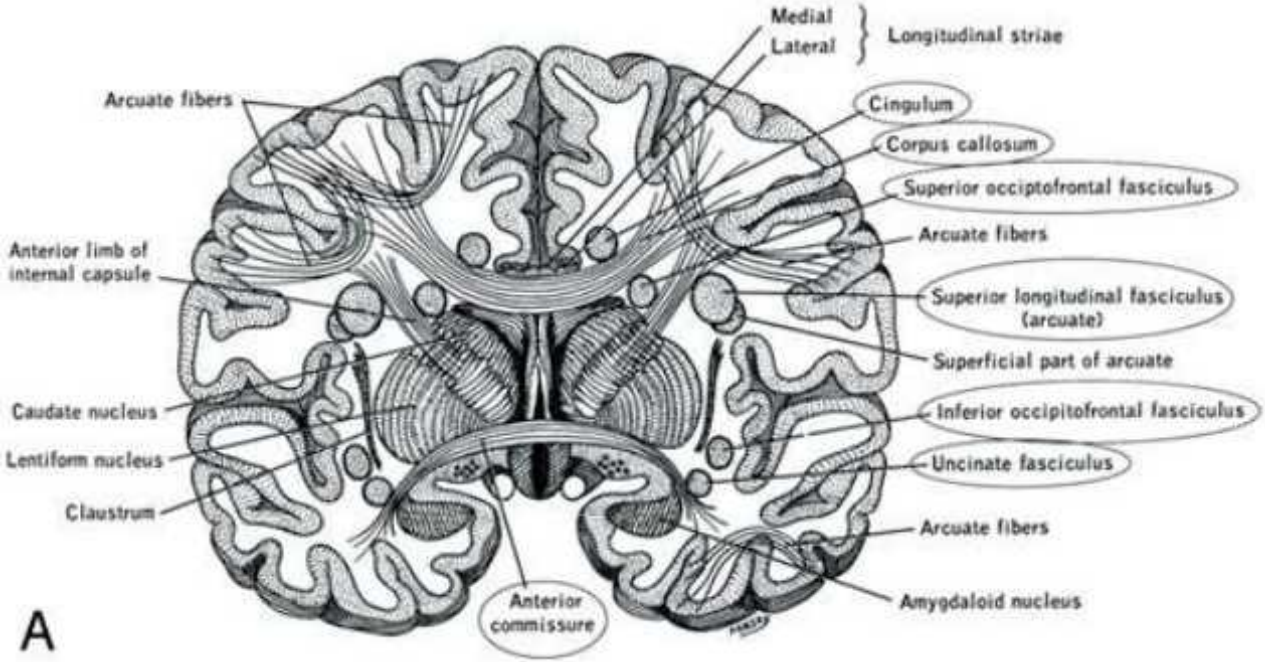
- MRI technique that uses anisotropic diffusion to estimate the axonal (white matter) organization of the brain

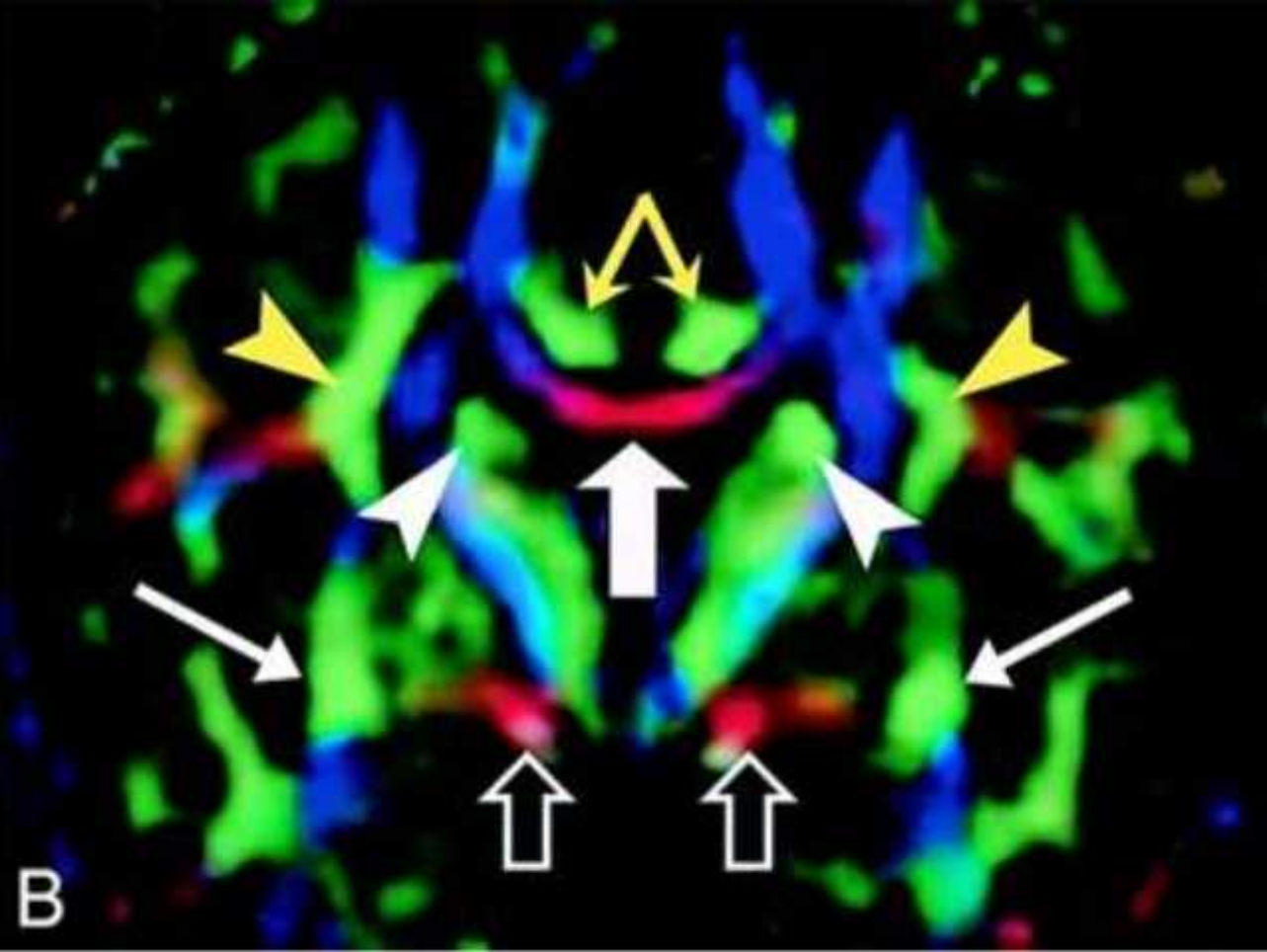

Isotropy
Low anisotropy
High anisotropy
A
B
C
D
E
Fractional anisotropy (FA)

- Ellipsoidal visualization of diffusion tensor data



http://graphics.cs.ucdavis.edu/~lfeng/sig/tensor/papers/MR%20diffusion%20tensor%20imaging%20recent%20advance%20and%20new%20techniques%20for%20diffusion%20tensor%20visualization%20science.pdf

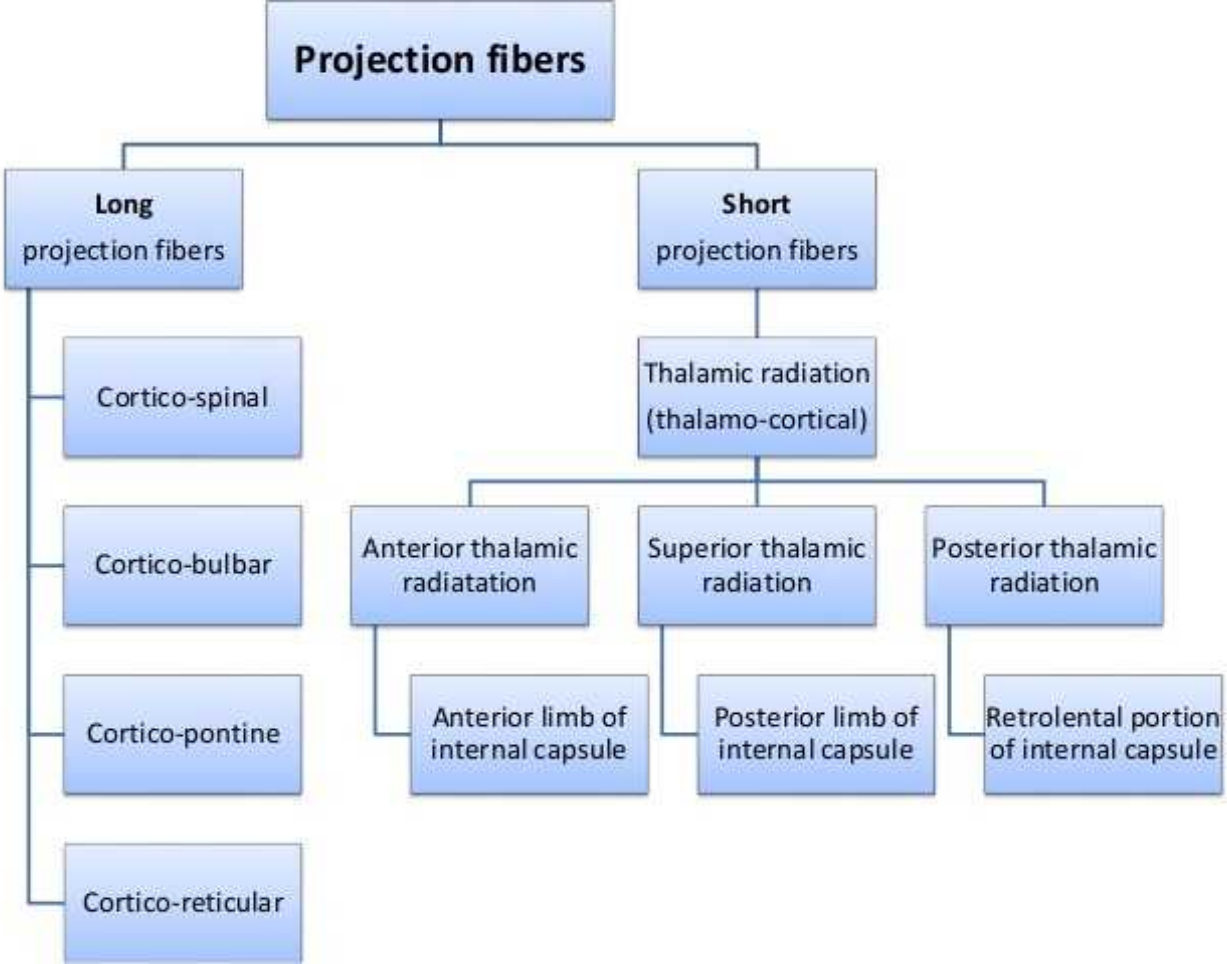

Medial
Lateral
Longitudinal striae
Arcuate fibers
Cingulum
Corpus callosum
Superior occiptofrontal fasciculus
Arcuate fibers
Anterior limb of internal capsule
Superior longitudinal fasciculus (arcuate)
Superficial part of arcuate
Caudate nucleus
Inferior occipitofrontal fasciculus
Lentiform nucleus
Uncinate fasciculus
Claustrum
Arcuate fibers
Anterior commissure
Amygdaloid nucleus
A

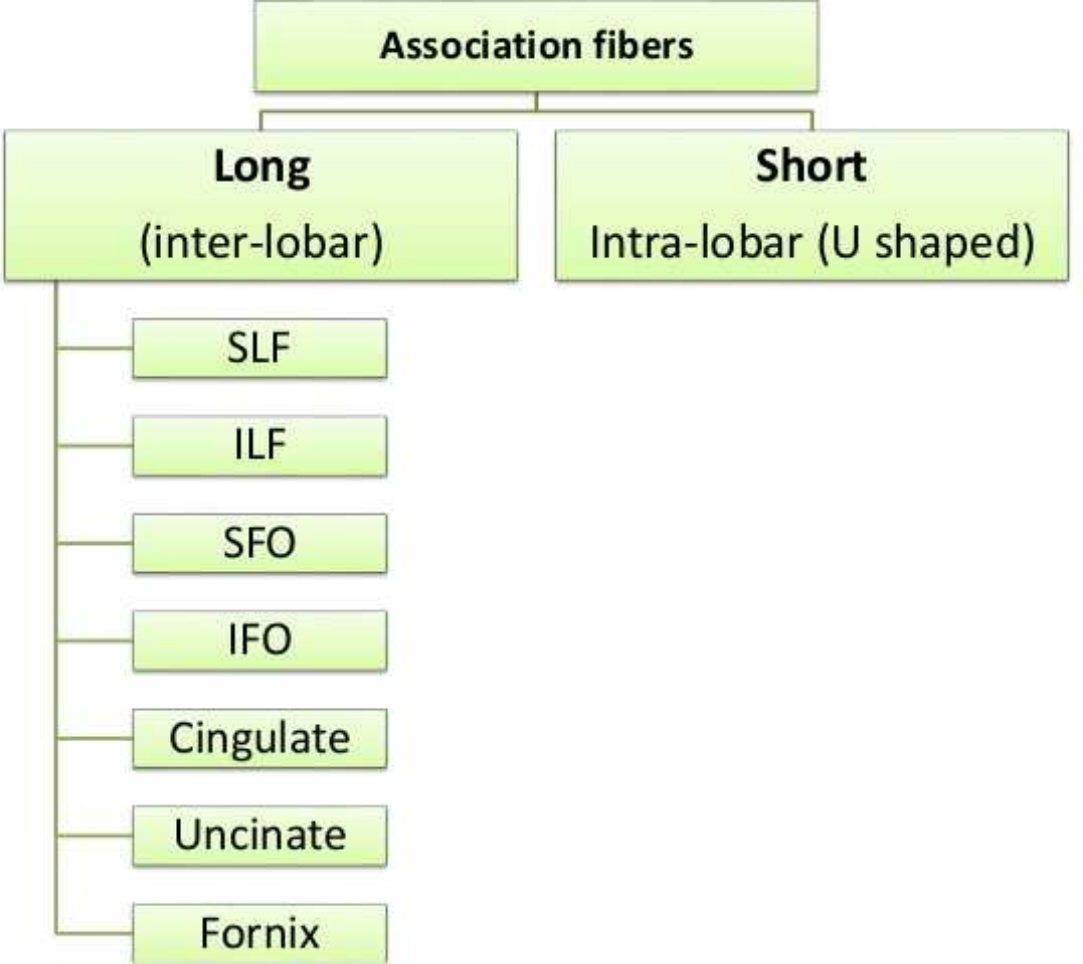

B

Fiber tractography (FT)

- is a 3D reconstruction technique to access neural tracts using data collected by DTI.

Color coding of fiber tractography		
Red	Commisural fibers	Right → left hemisphere
Blue	Projection fibers	Cortex → subcortical grey matter
Green	Association fibers	Cortex → cortex


Projection fibers
Long projection fibers
Short projection fibers
Cortico-spinal
Cortico-bulbar
Cortico-pontine
Cortico-reticular
Thalamic radiation (thalamo-cortical)
Anterior thalamic radiatation
Superior thalamic radiation
Posterior thalamic radiation
Anterior limb of internal capsule
Posterior limb of internal capsule
Retrolental portion of internal capsule


Association fibers
Long
(inter-lobar)
Short
Intra-lobar (U shaped)
SLF
ILF
SFO
IFO
Cingulate
Uncinate
Fornix